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Scientific, Technical and Economic Committee for Fisheries (STECF) - 2018 Mediterranean Stock Assessments – Part II (STECF-18-16)

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Joint Research Centre

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Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report deals with the 2018 Mediterranean stock assessments – Part 2.

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) – 2018 Mediterranean Stock Assessments – Part II (STECF-18-16)

Request to the STECF

The STECF is requested to review the report of the STECF Expert Working Group meeting, evaluate the findings and make any appropriate comments and recommendations.

STECF observations

The Mediterranean expert working group 18-16 met in Rome from 15 to 21 October 2018. 12 experts attended the meeting including two JRC experts, two STECF members and one observer. The stock assessments performed in EWG 17-15 and 18.16 should constitute the basis for the preparation of the demersal Adriatic EU MAP.

STECF comments

STECF invited an external reviewer to participate in the EWG, with the specific purpose of reviewing the hake assessment but also participating in the group discussion for all the stocks. STECF notes that the report contains a review of the hake assessment.

Overall STECF considers that the EWG addressed thoroughly all ToRs. A total of seven area/species combinations were evaluated.

Table 1. List of stocks assessed in the EWG 18-16.

Area	**Common name**	**Scientific name**
GSA 17-18 (see TOR 7)	Hake	***Merluccius merluccius***
GSA 17-18	Red mullet	***Mullus barbatus***
GSA 17-18	Norway lobster	***Nephrops norvegicus***
GSA 17-18-19	Deep-water rose shrimp	***Parapenaeus longirostris***
GSA 17-18	Common cuttlefish	***Sepia officinalis***
GSA 17	Sole	***Solea vulgaris***
GSA 17-18	Spottail mantis shrimp	***Squilla mantis***

The stock areas joining several GSAs have been proposed on the basis of STOCKMED and management needs. The EWG followed the area combination noted above and in giving catch options, but STECF has noted below where area combination may need additional consideration.

Overview

5 assessments were carried out using age-based methods including short term forecasts, one with a stochastic surplus production model in continuous-time (SPICT) and other using both SPICT and CMSY. The status of each stock in terms of spawning biomass and fishery exploitation was evaluated. Catch advice was provided based on applying an MSY approach and other catch options are made available in the summary sheets section 5 of the report.

The quality of the assessments produced was carefully reviewed by the experts, including the external reviewer, during the EWG. Some of the uncertainties and assumptions made by the EWG were further discussed by the STECF (see below). Overall, while STECF recognises that some uncertainty still remain regarding key biological parameters of e.g. growth and stock identity that would warrant further scientific investigations, the assessments presented by EWG 18-16 represent the best available estimates of the current status of the stocks. STECF notes furthermore that most of the stocks had been assessed in 2017 and the outcomes had been reviewed during the 2018 Spring Plenary meeting (PLEN 18-01). The present review in PLEN 18-03 builds therefore on the evaluations and comments agreed during the STECF 2018 Spring Plenary. The quality of each assessment and the methodological changes compared to Spring Plenary assessments are discussed below.

STECF considers that six of the seven assessments presented can be used to give advice on stock status, and are indicative of changes in F or catch. STECF notes that for sole in GSA 17 there are uncertainties in the age information, as discussed below. STECF recognises that all these assessments come from short data series and are therefore intrinsically uncertain, but considers overall that they provide a good guide to the magnitude of changes required to reach F_{MSY} in 2019.

STECF notes that the EWG has estimated and provided values of F_{MSY} and MSY ranges for all seven stocks. The values of F_{low} and F_{MSY} are regarded as reasonable estimates, are considered precautionary and may be used directly to give FMSY advice as long as the stocks are above B_{pa}. However, the EWG has not been able to evaluate these ranges following the usual procedure as used by ICES. Therefore, STECF does not advise fishing at F greater than F_{MSY} for any stock, and notes that the advice for Norway lobster is for $F<F_{MSY}$ due to the low biomass $B<B_{pa}$

A brief description of status of the assessed stocks and advice regarding the measures needed to reach F_{MSY} in 2019 are listed below. Overall, the assessments indicate that all stocks but one are significantly being overfished, but also that biomass is stable or increasing for all stocks.

- Hake in GSA 17 -18 is increasing but is being overfished. Catches should be reduced by at least 55% to reach F_{MSY} in 2019.
- Red Mullet in GSA 17-18 is increasing but is being overfished. Catches should be reduced by at least 10% to reach F_{MSY} in 2019.
- Norway Lobster in GSA 17-18 : is stable over the recent years but SSB is estimated to be below B_{pa}, F is above F_{msy} and F need to be reduced to below F_{MSY} in order to allow the stock to recover above B_{pa}. Corresponding catches should be reduced by at least 48% to reach $0.77*F_{MSY}$ in 2019.
- Deep water rose shrimp in GSA 17-18-19 is increasing but is being overfished. Catches should be reduced by at least 75% to reach F_{MSY} in 2019.
- Common Cuttlefish in GSA 17-18 is stable at B_{MSY} it is currently being under exploited relative to MSY. Common Cuttlefish is a short lived species and the catch advice for 2019 for this species depends almost completely on recruitment in 2018 which is unknown. The model assuming average recruitment estimates that catches may be doubled to reach F_{MSY} in 2019. If recruitment in 2018 differs from the average, catches should be modified accordingly.
- Sole in GSA 17 is stable but the stock is being overfished. Catches should be decreased at least 71% to reach F_{MSY} in 2019.

- Spotted mantis shrimp in GSA 17-18 is increasing and the stock is being overfished. Catches should be decreased at least 41% to reach F_{MSY} in 2019.

Statements on expected catch changes in relation to reaching FMSY in 2019 are included in the following table:
The table includes all the attempted approaches and highlight in bold the final choices which were the basis of the advice

Table 2. Summary of analyses that were attempted and basis for advice (given in bold). A4A, XSA, and SS3 are age-based assessment methods; STF is a standard short-term projection with assumptions of status quo F in the intermediate year (2018) and recent historic recruitment for 2018 and 2019. SPiCT and CMSY are surplus production methods.

Area	**Species**	**Previous Analysis / year**	**Attempted analyses and basis of advice (in bold)**
GSA 17-18	Hake	a4a/SS3 2017 (not accepted)	SS3**, a4a, STF**
GSA 17-18	Red mullet	Index 2017	**a4a, STF**
GSA 17-18	Norway lobster	SPICT 2017	a4a, **SPiCT, STF**
GSA 17-18-19	Deep-water rose shrimp	a4a XSA 2017	**a4a, STF**
GSA 17-18	Common cuttlefish	CMSY 2017	SPiCT, **CMSY**
GSA 17	Sole	a4a/SS3 2017 (not accepted)	a4a**, SS3**, **STF**
GSA 17-18	Spottail mantis shrimp	a4a 2017	XSA, **a4a STF**

Table 3. Summary of advice from EWG 18-12 by area and species. F 2017 is terminal F in the assessment. Change in F is the difference as % change between targeted F in 2019 (F_{MSY}) and the estimated F in 2017. Change in catch is % change from catch estimated 2017 to projected catch 2019. Biomass status for Norway Lobster and Cuttlefish is based on B_{MSY} estimated in the surplus production models. Biomass status for all other stocks is given as an indication of trend over the last 3 years for stocks with time series analytical assessments or biomass indices. ([L] indicated landing only, not catch).

Area	**Species**	**Method/ basis**	**F 2017**	**F 2019**	**Change in F**	**Catch 2017**	**Catch 2019**	**Change in catch**	**Biomass (status)**

GSA 17-18 (see TOR 7)	Hake	a4a	0.53	0.16	-70%	6035	2694	-55%	Increasing
GSA 17-18	Red mullet	a4a	0.48	0.41	-15%	5652	5083	-10%	Increasing
GSA 17-18	Norway lobster	SPiCT	0.66	0.35*	-47%	1430	745	-48%	$0.43B_{msy}$
GSA 17-18-19	Deep-water rose shrimp	a4a	1.69	0.65	-62%	10408	2635	-75%	Increasing
GSA 17-18	Common cuttlefish	CMSY	0.5 F_{MSY}	$F=F_{MSY}$	101%	3774	7600	101%	At B_{msy}
GSA 17	Sole	SS3	0.65	0.24	-63%	2257	659	-71%	Stable
GSA 17-18	Spottail mantis shrimp	a4a	1.04	0.41	-61%	4672	2742	-41%	Increasing

* The exploitation rate for *Nephrops* GSA 17-18 is based on a reduced harvest rate due to the low biomass ($B<B_{pa}$) F_{msy}= 0.45 is reduced to F=0.35

Data revision

STECF notes that the EWG received revised time series for the most recent years, regarding landings time series from Albania as reported to GFCM, and catch time series from Croatia.

In the case of Albania the new landings data for hake show a threefold increase in catch in the last 6 years over the previous 6 years and Albania now declares about 16% of the total Adriatic hake catch in comparison with 4% in the previous period. For Norway lobster Albanian catches were declared as zero prior to 2012, while over following period 2012-2017 they amounted on average 24% of the total Adriatic landings. For deepwater rose shrimp the declared landings for Albania have risen sixfold since 2012 and now constitute 33% of the total declared landings. This revision has minor influence on the perception of the status of the stocks of hake and Norway lobster, but has a larger impact on the estimate of deep water rose shrimp biomass.

For Croatia the reported otter trawl discard rates of hake for last 4 years have been reduced, from around 10% to 0.2% of Croatian catch, this compares with around 3% discard rates for Italian otter trawl. Overall Croatian discards contribution has reduced from 1.4% to 0.03% of total catch. This change is likely negligible for overall perception of hake stock status but may give misleading impression of the selection at age or length in the fishery.

STECF understands that these revisions in Croatian discard data seem to be associated with a change in data sources, where discard estimates now come from the information directly reported by fishers in the log-books. STECF considers that this methodology is likely flawed, unless it can be proven with independent sources that discards are reliably estimated and declared in logbooks. These estimates should thus be corroborated by discard observations from at-sea monitoring programs, such as last haul program, on board sampling or electronic monitoring. STECF notes also that according to most recent Work Program and Annual Report from Croatia evaluated by EWG 18-18, discard sampling is still ongoing in this Member State, so further clarification on the reliability of the discard estimation should be sought.

STECF comments that in the view of these large changes and revisions of the most recent data years, the overall reliability of the early part of the time series of catches for the stocks concerned should be assessed.

Specific comments by stock

For hake in GSA 17-18, STECF noted in 2018 Spring Plenary F noted that, "*based on results of both models STECF is able to conclude that F is high, greater than FMSY and that catches need to be reduced by a half as a minimum to achieve FMSY in 2019. STECF is not able to advise on the current state of biomass for this stock*". STECF PLEN 18-01 recognised the need to improve this stock assessment. STECF thus organised external review to help develop models for this stock in EWG 18-16. STECF highly appreciates the extra model exploration in the EWG dedicated to the assessment of Mediterranean hake (*Merluccius merluccius*) in GSA 17-18 and more specifically the development of an assessment based on Stock Synthesis (SS3). Substantial progress has been achieved during EWG 18-16 and SS3 estimates of biomass and fishing mortality for the most recent data year (2017) are similar to the a4a estimates. The historic differences are also small, with SS3 showing a slightly greater decline in stock over the time series. However, the SS3 model is less stable and the EWG suggested that a4a is the preferred model for advice. After considering the comments from the external review, STECF endorses this choice. STECF notes additionally that SS3 model allows separate modelling of fleets, whereas a4a uses a single combined fishery fleet. However, STECF notes that both modelling approaches can be used to derive partial fishing mortality by fleet if required for the development of multiannual plans, and considers both models could be considered for the development of management strategies evaluation (MSEs).

For red mullet in GSA 17-18, STECF 2018 Spring Plenary gave a catch advice based on a harvest rate informed by a biomass index. EWG 18-16 presented an improved, more stable assessment for this stock. STECF PLEN 18-03 considers that this assessment can be used to provide an estimate of F status relative to F_{MSY} and corresponding catch options for the whole area. STECF notes however that there is some information to suggest that red mullet may have more than one stock unit in the combined area, and the assessment provides thus an average exploitation rate valid for the whole unit. Care should be taken to ensure parts of the area are not overfished. Differences in biomass trends across the area may be monitored with indices from MEDITS survey.

For Norway lobster in GSA 17-18, STECF 2018 Spring Plenary gave advice based on a single area surplus production model. STECF has used the same methodology again this year to give advice, with the short term forecast carried out using the same assumptions as those agreed in PLEN 18-01. This updated assessment is coherent with last year's assessment, despite the revision of Albanian data, and is therefore considered suitable for overall evaluation of F and SSB and a short term forecast for 2019. STECF also note that the short term forecast catch option is based on a reduced fishing mortality ($F<F_{MSY}$) due to low biomass ($B<B_{pa}$). STECF considers that this reduction is required to rebuild the stock above B_{pa} and towards B_{MSY}.

STECF also notes that Norway lobster is known to grow differently in different parts of the Adriatic, and there may be potential for local depletion. Specific measures have already been put in place to restrict fishing in areas of perceived greater vulnerability. STECF considers that these area restrictions make a helpful contribution for protecting the more vulnerable areas. However, STECF underlines that area restriction is not a substitute for the overall reduction in fishing mortality advised, if overall catches do not decrease. STECF notes additionally that the EWG 18-16 carried out a series of sensitivity tests for the different growth rates observed in different parts of the Adriatic. STECF considers that while these tests are helpful to understand the sensitivity of the assessment to alternative assumptions on growth, they do not provide an assessment of stock status within the different parts of the area, as they are not based on catch from the different parts of the area.

For deep water rose shrimp in GSA 17-18-19 the update assessment performed by EWG 18-16 gives a similar perception of the stock in recent years compared to the assessment agreed in Spring Plenary. Additionally the new assessment has been extended back in time. The added early period should however be treated with caution. The fluctuations seen in the first few years are driven by intermittent observations of specific year classes. It has not been possible to validate the detail of these observations. The catch data in the most recent years is of higher quality and reliability, and is suitable to evaluate the status of the stock in recent years.

For common cuttlefish in GSA 17-18 STECF did not give advice in Spring Plenary. While it appears possible from the EWG 18-16 assessment to estimate the state of the stock on the basis of the improved time series of catch data, STECF notes that it is not possible to give specific catch advice for 2019, due to the short lived nature of this species. STECF has therefore provided an advice for 2019 based on average estimate of catch.

For sole in GSA 17 STECF 2018 Spring Plenary 'discussed *the various hypotheses and evidences underpinning the various models, and noted that this might be further analysed by STECF 18-16. Although no unanimous conclusion could be reached by the committee, it is suggested that unless new conclusions are reached by EWG 18-16, the intermediate SS3 model (SS3 Run7 section 6.8.3) with intermediate levels of cryptic biomass (around 15% of adult biomass not accessible to the fishery) is used as the main basis for MAP analyses in STECF 18-17'.* The EWG 18-16 has noted the deficiencies in aging sole, and has evaluated an alternative length slicing approach. STECF considers however that this length slicing approach needs further evaluation and development. Therefore, STECF PLEN 18-03 suggests again, as during Spring Plenary, that the SS3 model (now updated with 2017 data and reported in EWG 18-16 Section 6.6.3.1) is used as the main basis for MAP analyses in STECF 18-17. STECF anticipates that once ageing issues have been resolved, further updates of input data will be available for this assessment and at that point the assessment should be updated.

For spottail mantis shrimp in GSA 17-18 STECF notes that the current assessment is an update of the assessment that was used by STECF Spring Plenary to give information on F status and catch options, with the only addition of 2017 data. The updated model is on the same basis and is giving similar results in terms of F and SSB as presented in PLEN 18-01. STECF therefore considers that this updated assessment should be used to give catch options for 2019.

Additional comments

During the STECF Plenary 18-03 meeting, an STECF member has provided a summary of potential issues for the EWG 18-16 assessments. These issues have been discussed among the EWG 18-16 experts after the STECF plenary, but before the publication of the final EWG 18-16 and PLEN 18-03 reports. The comments have been included as Annex A to the EWG report, together with the following EWG 18-16 response. Where immediately possible the issues been dealt with by improvement to the draft text of EWG report and revisions to Tables and Figures, so that the comments are directly reflected in the final published version of the EWG 18-16 report. In other cases where further exploration is required, outside the scope of the current EWG, this aspect has been highlighted in the Annex A. The corrections brought to the EWG 18-16 assessment compared to the draft version reviewed by the PLEN 18-03 are minor: an error in stock weights has been found for Deep water rose shrimp in GSA 17 and 18, but these do not no change the catch advice or the stock status. For sole in GSA 7 minor corrections have been made to total catch in both SS3 and a4a assessments. This change slightly revised the assessment but have not substantively affected the outcomes of STECF PLEN 18-03 comments and conclusions. The a4a assessment has been revised due to revisions in natural mortality and maturity at age. The report has been revised, but as this assessment is not used by STECF for advice, the changes have no impact on STECF advice.

STECF notes that data quality deficiencies and recommendations for further research studies and data collection have been comprehensively addressed by the EWG for each stock in section 7 of the report. Due to the shortness of the time series, it has not been possible to carry out full evaluations of MSY ranges. The EWG 18-16 has thus provided simple MSY ranges based on a regression approach for the stocks considered.

The Italian MEDITS surveys in both GSA 17 and 18 were performed in a later period than the usual one (Spring) in several years, and especially in 2017. This issue has been extensively discussed by EWG 18-16, STECF considers that it is fundamental to respect the timing protocols for conducting trawl surveys. Differences in survey timing may produce misleading signals on abundance and age composition of the stock, which cannot be easily corrected and accounted for in the stock assessment model. Changing survey periods may have an adverse effect on the quality of survey data used as tuning index and increased the uncertainty in abundance indices and distribution patterns data series. The failure to comply with agreed timing protocols for surveys necessarily results in recognition of a failure to carry out a mandated task. STECF endorses the EWG considerations and has conveyed them to DG Mare and RCGs via inclusion in the sections 5.1 and 5.2 of this plenary 18-03 report.

Finally, STECF notes that some conceptual analyses have been carried out by the EWG regarding the suitability of the use of combined indexes of surveys carried out in different areas /countries /seasons (section 2 of the EWG report). For some areas and stocks, multiple surveys covering several GSAs are used as separate tuning indices for stocks distributed over several GSA. The analyses carried out by the EWG shows that it is always better to use a combined index rather than separate indices, since the combined index is less sensitive to the effects of movement (differences in distribution) before the surveys start, and ensures that the weighting of the multiple survey information in the model is dealt with consistently.

STECF conclusions

STECF acknowledges that the EWG was able to address all the terms of reference completing the evaluations of all GSA/species combinations requested, and to provide catch advice for 2019.

STECF acknowledges that important improvements have been made regarding the assessment of the stocks.

Overall, while STECF recognises that some key biological parameters of e.g. growth and stock identity would warrant further scientific investigations, the assessment are robust to several sources of uncertainty and the status of the overall perception is that stocks are overexploited

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REPORT TO THE STECF

EXPERT WORKING GROUP ON

Mediterranean Stock Assessments Pt II

(STECF 18-16)

Rome, Italy,15-21 October 2018

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission's future policy in this area

Executive Summary

The working group was held in Rome, Italy, from 15 to 21 October 2018. The meeting was attended by 12 participants including two JRC experts and two STECF members and one part time observer.

A total of 7 area/species combinations were evaluated. The EWG has carried out 5 age based assessments with short term forecasts. Catch advice for two stocks is based on biomass surplus production methods. The methods tested, and selected, along with a summary of the results are provided in Tables in the report. Summary sheets by stock are provided giving state of the stock in terms of spawning biomass and fishery exploitation. Catch advice is provided based on applying an MSY approach along with other catch options. The input data and assessment settings and results are provided by stock.

It is considered that all of the seven assessments presented can be used to give advice on stock status, and indicative change in F or catch. It is recognised that some of these assessments come from short data series and are therefore intrinsically uncertain, but the STECF considers overall that they provide a good guide to the magnitude of changes required to reach Fmsy in 2019.

The report provides estimates of values of FMSY and MSY ranges for seven stocks. The values of F_{low} and F_{MSY} are regarded as reasonable estimates that can be expected to be precautionary and thus may be used directly. The values for F_{upper} are indicative only; they have not been evaluated as precautionary and should not be used as such without further evaluation. For one stock (Nephrops in GAS 17-18) the stock is estimated to be below B_{pa} and the EWG provides advice at 0.77MSY in order to allow the stock to recover above B_{pa}.

The report also notes the data quality deficiencies have been comprehensively addressed by the EWG for each stock in section 7 of the report,

1 INTRODUCTION

1.1 Approach to the work

The working group was held in Rome, Italy, from 15th to 21st Oct 2018. The meeting was attended by 12 experts in total, including two STECF members and two JRC experts. The EWG had one observer who attended part time.

The objective of the Mediterranean Methodology EWG 18-12 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:15 on the first day. The ToRs were discussed and examined in detail.

Stocks were allocated to participants based on expertise.

An ftp repository was created ad-hoc to share documents, data and scripts and prepare the report.

The stocks were evaluated by the GSA groups identified in the ToRs. In all but one case there was sufficient data to attempt age based analytical assessments.

Plenary sessions were held each day to monitor progress and share results. The overall conclusions for each stock were discussed and finalized in plenary on the last day.

1.2 Terms of Reference for EWG-18-16

DG MARE focal persons: Chato Osio (MARE D1), Venetia Kostopoulou (MARE C3)

Chair: John Simmonds

GENERAL GUIDELINES: unless the data used and information provided comes from the official DCF data calls, the experts are requested to indicate the data source from where certain information has been taken (e.g. L-W relationships, prices) or if it is an experts' reasoned guess.

Data collected outside the DCF shall be used as well and merged with DCF data whenever necessary and following quality check. Due account shall also be given to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR and EU funded research projects, studies and other types of EU funding.

The raw data used to generate the input data, assessment scripts as well as input files should be made available to the JRC for reproducibility of the assessments and compilation of the STECF stock assessment database (https://stecf.jrc.ec.europa.eu/dd/medbs/ram)

*STECF 17-07*1 *defined methodological guidelines to ensure standardized practices for the preparation of stock assessment input data. EWG 18-16 should adhere to these recommendations referring to the need of:*

i) coherence of all growth parameters used in the assessments;

ii) improvement in documenting and defining the growth models and age slicing;

iii) test where possible age slicing by sex;

iv) t_0 should be truncated to values between 0 and -0.2;

v) review the raw age length data, where necessary refitting growth models (section 2.2 in the EWG 17-07 report).

For the stocks given in Annex I, the EWG 18-16 is requested:

ToR 1. Data preparation for the stock assessments:

1. To compile and provide the most updated information on stock identification and boundaries, length and age composition, growth, maturity, feeding, essential fish habitats and natural mortality.
2. To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2017. This should be presented by fishing gear as well as by size/age structure (see Annex II for more details).
3. To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2017. This should be described in terms of amount of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size (linear and/or GT), engine power kW, etc.) by Member State/Country and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort and/or capacity baseline (see Annex II for more details).
4. To compile and provide indices of abundances and biomass by year and size/age structure for the longest time series available up to and including 2017 by GSA and Country (see Annex II for more details).

ToR 2. To assess trends in historic and recent stock parameters on fishing mortality, stock biomass, spawning stock biomass, and recruitment. Different assessment models should be applied as appropriate, including retrospective analyses. The selection of the most reliable assessment shall be explained. Assumptions and uncertainties shall be specified.

The stock assessments performed in EWG 17-15 and 18-xx will constitute the basis for the preparation of the demersal Adriatic EU MAP. The MAP will require an extensive

[1] https://stecf.jrc.ec.europa.eu/documents/43805/1691180/STECF+17-07+-+Methods+for+stock+assessments+in+MED_JRCxxx.pdf

management strategy evaluation (MSE) in line with the work performed in STECF 16-21 and STECF 15-09. Since the MSEs, encoded in the Fisheries Libraries in R (FLR), rely on established routines where uncertainty and risk play an important role, it is priority for the EWG to:

1. Give preference to models that allow estimation of uncertainty, in line with the recommendations of STECF EWG 17-07.

2. To envision alternative stock assessments models or model configurations for the potential conditioning of operating models in the context of future MSEs.

ToR 3. To estimate candidate MSY point-value, MSY range values and conservation reference points (precautionary and limit) in terms of fishing mortality and stock biomass. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.

ToR 4. To provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, *inter alia*: zero catch, the status quo fishing mortality, and target to F_{MSY} (including the ranges) or other appropriate **proxy by 2020**. In particular, on the basis of the average commercial catch rates, estimate the level of fishing effort exerted by the different fleets which is commensurate with the short- and medium-term forecasts of the proposed scenarios.

ToR 5. To summarize and concisely describe all data quality deficiencies, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched on the March 2018. Identify further research studies and data collection which would be required for improved fish stock assessments. **This review shall be presented in a manner that is compatible with the online platform developed by the JRC for data issues[2].**

ToR 6. To provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits, and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including MSY value, range of values and conservation reference points.

ToR 7. Extra model exploration should be dedicated to the assessment of Mediterranean hake (*Merluccius merluccius*) in GSA 17-18. Make use of the data emerging from the

[2] Castro Ribeiro C. (2015) Fisheries Data Collection Framework - The DCF Reporting and Implementation Cycles and the Data End-user Feedback, JRC Technical report.

DCF/DCRF and any additional data as deemed necessary and carry out the following tasks:

5. Identify potential assessment models to be applied given the data at hand.
6. Apply potential models from past assessments, including SS3, XSA and a4a.
7. Select the best final model to be used, based on a thorough analysis of model diagnostics and investigating, the consistency of results among models explaining, when necessary, any inconsistencies.
8. Calculate reference points, in particular F_{MSY}, B_{PA} and $B_{LIM.}$
9. Provide a quantitative advice on the status of the stocks based on the outcomes of the chosen models with respect to the calculated reference points.
10. The identification of all outstanding problems associated to the assessment(s) of a resource (including on data, assumptions and methodologies).

Table I – List of suggested stocks to be assessed by the EWG 18-16.

Area	**Common name**	**Scientific name**
GSA 17-18 (see TOR 7)	Hake	***Merluccius merluccius***
GSA 17-18	Red mullet	***Mullus barbatus***
GSA 17-18	Norway lobster	***Nephrops norvegicus***
GSA 17-18-19	Deep-water rose shrimp	***Parapenaeus longirostris***
GSA 17-18	Common cuttlefish	***Sepia officinalis***
GSA 17	Sole	***Solea vulgaris***
GSA 17-18	Spottail mantis shrimp	***Squilla mantis***

NOTE: The joint assessments have been proposed on the basis of STOCKMED and management needs. However, these suggestions can be modified according to experts' knowledge and to the most recent scientific information.

ANNEX I

ANNEX II

Guidance for the preparation of the final report

<table>
<tr><td>SECTION 1.5</td><td>FISHERIES</td><td><u>Landings</u>
Total landings/year/Country *
Landings/fishing gear/year *
Landings /fishing gear/year/size structure
Landings /fishing gear/year/age structure
<u>Discards</u>
Total discards/year/Country *
Discards/fishing gear/year *
Discards/fishing gear/year/size structure
Discards/fishing gear/year/age structure
<u>Fishing effort</u>
Fishing effort (GT*days at sea)/year/Country *
Fishing effort (GT*days at sea)/fishing gear/year *
Fishing effort (Days at sea)/year *
Fishing effort (Days at sea)/fishing gear/year *</td></tr>
<tr><td>SECTION 1.6</td><td>SCIENTIFIC SURVEYS</td><td>Abundance index/year
Abundance index/year/size structure
Abundance index/year/age structure
Biomass index/year
Biomass index/year/size structure
Biomass index/year/age structure</td></tr>
<tr><td>SECTION 1.7</td><td>STOCK ASSESSMENT</td><td><u>Results</u> *
Fishing mortality
Fishing mortality/fishing gear
Recruitment
SSB
TB
<u>Reference points</u> *
F_{MSY}, F_{upper} and F_{lower}
B_{MSY}, B_{lim}, B_{pa}</td></tr>
</table>

		<u>Predictions</u> * *For the different scenarios,* Fishing mortality Fishing mortality/fishing gear Catches Catches/fishing gear Fishing effort/fishing gear SSB

* *Please, provide these variables at least in numerical values and where appropriate also with figures.*

2 FINDINGS AND CONCLUSIONS OF THE WORKING GROUP

A total of 7 area/species combinations were evaluated. The EWG has carried out and accepted 5 age based analytical assessments with short term forecasts, F target and catch advice for 2019 in addition two stocks were evaluated using surplus production models.

2.1 STOCK-SPECIFIC FINDINGS & CONCLUSIONS

See the stock specific summary sheets (section 5) for the main details by stock, and the assessments (Section 6) for full details. This section provides collated information on methods and stock status. The methods tested and chosen by stock are provided in Table 2.1. Where possible age based assessments are used, where these do not provide stable enough models, for those without sufficient length of age structure but longer series of catch available surplus production methods were used. The results in terms F and catch and relative changes from 2017 to 2019 are provided in Table 2.2.

Table 2.1 Summary of work was attempted and basis for any advice. A4A, XSA, are age based assessment methods; SPiCT and CMSY are surplus production models. STF is a standard short term projection with assumptions of status quo F and historic recruitment.

Area	Species	Previous Analysis / year	Attempted analyses and basis of advice (in bold)
GSA 17-18 (see TOR 7)	Hake	A4a/SS3 2017 (not accepted)	SS3**, A4a, STF**
GSA 17-18	Red mullet	Index 2017	**A4a, STF**
GSA 17-18	Norway lobster	SPICT 2017	A4a, **SPiCT, STF**
GSA 17-18-19	Deep-water rose shrimp	A4a XSA 2017	**A4a, STF**
GSA 17-18	Common cuttlefish	CMSY 2017	SPiCT, **CMSY**
GSA 17	Sole	A4a/SS3 2017(not accepted)	SS3, **a4a, STF**
GSA 17-18	Spottail mantis shrimp	2017	XSA, **a4a STF**

Table 2.2 Summary of advice from EWG 18-16 by area and species. F 2017 is terminal F in the assessment. Change in F is the difference (as a fraction) between target F in 2019 and the estimated F for 2016. Change in catch is from catch 2017 to catch 2019. Biomass status is given relative to BMSY where available, and as an indication of trend over the last 3 years for stocks with time series analytical assessments, biomass indices. For stocks based on surplus production methods F is estimated as a harvest rate (catch/biomass) relative to MSY. For Nephrops exploitation is reduced below Fmsy due to the low biomass which is estimated to be below Bpa.

Area	**Species**	**Method/ basis**	**F 2017**	**F 2019**	**Change in F**	**Catch 2017**	**Catch 2019**	**Change in catch**	**Biomass (status)**
GSA 17-18 (see TOR 7)	Hake	a4a	0.53	0.16	-70%	6035	2694	-55%	Increasing
GSA 17-18	Red mullet	a4a	0.48	0.41	-15%	5652	5083	-10%	Increasing
GSA 17-18	Norway lobster	SPiCT	0.66	0.35*	-47%	1430	745	-48%	$0.43B_{msy}$
GSA 17-18-19	Deep-water rose shrimp	a4a	1.69	0.65	-62%	10408	2635	-75%	Increasing
GSA 17-18	Common cuttlefish	CMSY	0.5 F_{MSY}	$F=F_{MSY}$	101%	3774	7600	101%	At B_{msy}
GSA 17	Sole	SS3	0.65	0.24	-63%	2257	659	-71%	Stable
GSA 17-18	Spottail mantis shrimp	a4a	1.04	0.41	-61%	4672	2742	-41%	Increasing

* The adised exploitaion rate for nephrops GSA 17&18 is based on a reduced harvest rate due to the low biomass (B<Bpa) Fmsy= 0.45 is reduced to F=0.35

2.2 QUALITY OF THE ASSESSMENTS

The major methodological issues organised by species are discussed here, the main details are provided in the individual assessment sections (Section 6) and the important issues for assessment and data quality are summarised in the advice sheets (Section 5). There are revisions to assessments of Deep Water Rose Shrimp (DPS) in 17-18-19 due to the alignment of growth slicing with spawning time. In the case of sole in GSA 17, the EWG received official data based on aged individuals on the same basis as 2017 assessment. The EWG is aware of revisions to this data being considered imminently. The EWG compared growth model based methods with the age data and concluded they were different. There was insufficient time to develop a full length based assessment (this has taken many months for hake), but age slicing appears to be particularly reliable for sole in GSA 17, so this was implemented using published growth curves and includes evaluations of sensitivity to growth assumptions. For the details see Section 6.6

The EWG was requested (ToR 7) to develop a models for hake in GSA 17-18. Following extensive work by several people, both before and during the EWG aimed developing a more detailed fishery model using SS3. Substantial progress has been made with this model and now both SS3 and a4a models assess the stock to be a similar biomass and fishing mortality in 2017, and negligibly different short term forecasts. The historic differences from both models are also minor; with SS3 currently showing a slightly greater decline in stock over the time series. However, retrospective analysis shows that the SS3 model is less stable and for the moment is the preferred model for advice. It is expected that there will be further development of both models, but particularly the SS3 model with the aim of a benchmark in December.

2.3 EFFORT DATA. (TOR 1.3)

ToR 1.3: To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2017. This should be described in terms of amount of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size (linear and/or GT), engine power kW, etc.) by Member State/Country and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort and/or capacity baseline (see Annex II for more details).

As the main species in the Adriatic are caught by a small range of gears, with several species in mixed fisheries, the analysis of effort data was done for all species in the ToR and all reported gears together, providing a summary of the most important gears and their effort in a single section.

2.3.1 SOURCE OF THE DATA

- DCF Mediterranean data call (DCF MED)
    - Effort data
    - Landing data
- Economic and Transversal data table from Annual Economic report (TRANSVERSAL DATA)
    - Table EU Fleet effort FAO Gear level (STECF 18-07)
    - Table EU Fleet Economic and Transversal data fs level (STECF 18-07)

2.3.2 SELECTION OF THE RELEVANT FISHING GEAR

Selection of the most important gears for analysis were done on the basis of data on landing of selected species coming from Transversal data on landing for period 2013 - 2016. For each species percentage of landing has been calculated for each fishing gear separately, and then fishing gears were ranked on by percentage. For further analysis, only gears with percentage in the total landing of each species bigger than 5% were taken. In the case that some fishing gear participate in the landing of certain species in the other country with proportion bigger than 5%, it was also taken for other countries in which proportion was smaller than 5% (with aim to cover as much as possible part of the landing of certain species in the Adriatic Sea).

Finally, on the basis of data on landing by countries the EWG selected the most important gears for each species on the Adriatic level taking in consideration that all relevant gear by countries should be included in the list. Using this methodology, the seven following fishing gears were selected: Bottom Otter Trawl (OTB), Boat Dredge (DRB), Beam Trawl (TBB), Trammel Net (GTR), Set Gillnet (GNS), Pots and Traps (FPO) and Set Longlines (LLS) (Table 2.3.1.)

Table 2.3.1. Percentage in the landing of ToR species for the most important fishing gear by countries for whole period covered by DCF MED Data Call.

	HRV		ITA		SVN		TOTAL	
CTC								
	OTB	41.56	OTB	45.29	OTB	56.39	OTB	45.13
	DRB	23.83	FPO	17.46	GTR	37.45	FPO	16.62
	GTR	16.38	TBB	14.44			TBB	13.74
	GTN	10.19	GNS	9.38			GNS	9.06
			GTR	5.95			GTR	6.48
		91.95		*92.52*		*93.84*		*91.03*
DPS								
	OTB	99.93	OTB	99.99			OTB	99.96
		99.93		*99.99*				*99.96*
HKE								
	OTB	85.14	OTB	90.36	OTB	69.50	OTB	89.25
	LLS	8.86	LLS	8.33	GNS	28.94	LLS	8.44
	GNS	5.42						
		99.43		*98.70*		*98.44*		*97.70*
MTS								
	OTB	91.75	OTB	82.03	OTB	66.70	OTB	82.05
			GNS	7.59	GTR	22.47	GNS	7.57

			TBB	5.13	GNS	6.70	TBB	5.12
		91.75		*94.75*		*95.87*		*94.74*
MUT								
	OTB	98.44	OTB	96.28	OTB	99.54	OTB	96.87
		98.44		*96.28*		*99.54*		*96.87*
NEP								
	OTB	89.13	OTB	99.53			OTB	96.91
	FPO	10.55						
		99.68		*99.53*				*96.91*
SOL								
	GTR	72.39	TBB	50.66	GTR	86.12	TBB	43.68
	DRB	17.48	OTB	24.53	GNS	11.92	OTB	22.03
	OTB	6.70	GNS	20.63			GNS	18.15
							GTR	13.66
		96.58		*95.81*		*98.04*		*97.53*

In the Table 2.3.2. Data on percentage in the landing of selected ToR species for the most important fishing gear by countries are given only for last year 2017.

Table 2.3.2. Percentage in the landing of selected ToR species for the most important fishing gear by countries for year 2017.

		HRV		ITA		SVN		TOTAL
CTC	OTB	33.46	OTB	59.22	OTB	48.87	OTB	58.47
	DRB	28.53	TBB	14.18	GTR	43.70	TBB	13.76
	GTR	19.27	GTR	12.16	GNS	4.27	GTR	12.39
	GNS	11.99	FPO	10.37			FPO	10.08
CTC TOT		*93.25*		*95.93*		*96.85*		*94.69*
DPS	OTB	99.95	OTB	100.00			OTB	99.97
DPS TOT		*99.95*		*100.00*				*99.97*
HKE	OTB	84.60	OTB	86.38	OTB	80.53	OTB	86.05
	LLS	9.75	LLS	12.63	GNS	19.00	LLS	12.09
HKE		*94.35*		*99.00*		*99.54*		*98.14*

TOT								
MTS	OTB	91.73	OTB	81.14	OTB	54.35	OTB	81.17
			GNS	8.67	GTR	30.93	GNS	8.65
			GTR	5.40	FPO	7.99	GTR	5.40
					GNS	6.73		
MTS TOT		*91.73*		*95.21*		*100.00*		*95.21*
MUT	OTB	98.58	OTB	97.58	OTB	99.95	OTB	97.82
MUT TOT		*98.58*		*97.58*		*99.95*	*0*	*97.82*
NEP	OTB	79.73	OTB	100.00			OTB	96.13
	FPO	19.78					FPO	3.77
NEP TOT		*99.51*		*100.00*				*99.91*
SOL	GTR	72.05	TBB	60.23	GTR	83.17	TBB	54.18
	DRB	20.12	GNS	23.03	GNS	16.19	GNS	21.00
	OTB	4.77	OTB	16.67			OTB	15.46
	GNS	2.07					GTR	7.34
SOL TOT		*99.01*		*99.93*		*99.36*		*97.98*

2.3.3 EFFORT DATA

For analysis of effort data two source of the data were taken: DCF data (Effort table) and Economic and Transversal data table (STECF 18-07).

According DCF effort data fishing vessels from 5 EU countries participated in fisheries. Three of them are EU Adriatic countries (Croatia, Italy and Slovenia) and two non-Adriatic countries: Malta and Cyprus. In the 2017 two vessels from Malta were registered in the demersal fisheries using LLS and spent 9 fishing days in the GSA 17 with nominal effort of 2316.78 kW. In 2015 vessels from Malta operated in Adriatic sea: one using LLS with 26 days at sea (19 fishing days) and nominal effort of 11343 and other using OTB with 6 days at sea (1 fishing day) with nominal effort of 447,6. In 2017 two vessel from Cyprus were active in the Adriatic Sea: two LLS with 9 days at sea (9 fishing days) with nominal effort of 2316.78. This effort is negligible and not considered further in the analysis.

2.3.4 Remarks

Amount of vessels (number of vessels)

In the DCF effort tables the number of vessels is given by quarter, and not by year. So it is not possible from there to extract number of the vessel per fishing gear per country per year because one vessel can be active in one quarter and not in any the other. Thus the total number of vessels is not the average, or the maximum, over the four quarters. In the AER table of transversal data the number of vessels is not given by GSA but by countries, so it is not possible to extract number of vessels operating in the Adriatic for Italian side where they fish in several GSAs (including non Adriatic GSAs).

Traps (FPO) for Norway lobster and for Common cuttlefish

Traps (pots) is important gear for catching Norway lobster in Croatia (about 10% of total catch) and traps are not used in Italy and Slovenia for catching this species. This gear is used locally in Croatia (mainly in the channel area of Northern and central Adriatic) where is distributed part of Norway lobster population with individuals of larger size. But, from the Effort data tables it is not possible to distinguish FPO targeting Norway lobster from other traps targeting other demersal species. The same situation is for traps used in Italy for catching Common cuttlefish. In the next data calls Member States should be asked to provide data separately for FPO targeting Norway lobster and Common cuttlefish.

DRB and TBB

There is difference between countries in the Adriatic Sea regarding these fishing gears. In Slovenia this fishing gears is not used. In Italy DRB is used mainly to catch Mollusca (shellfish) (local name of this gear is “vongolara”), while in Croatia (local name “rampon”) this fishing gear is targeting shellfish, but significant part of the catches are of other species (Solea vulgaris, Sepia officinalis). Croatian rampon gear is very similar to the Italian gear locally called “rapido” which is putted in category beam trawl TBB. In Croatia beam trawl TBB is called “kogol” and in 2017 there was only one vessel with this gear working 21 days. In Croatia, this fishing gear is very similar to the OTB regarding its catches.

So, in the following analysis of effort only Italian TBB (“rapido”) was taken (mainly because of catch of sole) and Croatian DRB (“rampon”) because of catch of sole and cuttlefish.

2.3.5 Analysis by countries

For analysis of effort by countries data from DCF MED data call were used.

Italy

Following gears were chosen for analysis of effort of Italian demersal fleet: OTB, LLS, TBB, GNS and GTR. As previously mention, DRB was not taken into account due to fact that this fishing gear in Italy dominantly exploited shellfish, and FPO for Common cuttlefish because it is not possible to separate fishing effort coming from this traps from fishing effort coming from other traps targeting other demersal species.

Problem with data

During analysis some problems with Italian DCF MED Effort data set were recorded. The values in the category “days at sea” seems to be incorrect and too big. Namely, number of “days at sea” is several time higher than number of “fishing days” (in numerous cases number of fishing days make less than 1% of days at sea!). Also, when divided number of days at sea with number of vessels in the quartier of year very big and obviously biased values have been found (a few hundred or even few thousand days, and this value cannot logically be bigger than 90).

There is also problem in the value of “nominal effort” and “GT*days at sea”. From the definition, both of those values should be calculated as multiplication of kW or GT with number of days at sea. However, it seems in case of Italian data, those values were calculated using values of fishing days. EWG proposed that Italy should be asked to check DCF MED Effort data set (for all areas, as the problem occurs also in other GSAs fished Italian vessels), and to provide explanation and to validate the data.

Tramell Net (GTR)

Table 2.3.3. Detailed information on fishing effort of Italian GTR fleet by fleet segments

	NOMINAL EFFORT (ITA GTR)			
	VL0006	VL0612	VL1218	TOTAL
2004		2025808	198077	2223885
2005		1722176	68549	1790725
2006	14270	1211612		1225882
2007	10305	1777562		1787867
2008	154725	1760181		1914906
2009	141387	1772720	2736	1916843
2010	143662	2003106		2146768
2011	143902	2108698	34056	2286656
2012	80651	1966294		2046945
2013	101717	1562513	50223	1714453
2014	139231	973619		1112850
2015	45555	1254775		1300330
2016	102378	1236909		1339287
2017	61080	1124966	280109	1466154

	GT*DAYS AT SEA (ITA GTR)			
	VL0006	VL0612	VL1218	TOTAL
2004	0	146710	14585	161295
2005	0	143059	6911	149970
2006	21882	89190		111072
2007	12347	134614		146961
2008	18190	122566		140756
2009	18595	127140	285	146020
2010	19414	126709		146123
2011	24451	132996	2130	159577
2012	15744	123106		138850
2013	2147	65935	4148	72230
2014	13349	83296		96645
2015	5782	62356		68138
2016	6357	58926		65283
2017	15182	64593	20155	99930

	DAYS AT SEA (ITA GTR)			
	VL0006	VL0612	VL1218	TOTAL
2004	0	377877	167279	545156
2005	0	365656	106082	471738
2006	115264	208980		324244
2007	88662	207377		296039
2008	76205	202934		279139
2009	117478	208321	23407	349207
2010	111921	208234		320155
2011	117793	215984	98367	432144
2012	93577	210429		304006
2013	53531	128947	85574	268052
2014	86992	153641		240633
2015	54997	145426		200422
2016	55711	137476		193187
2017	15183	25432	1270	41885

	FISHING DAYS (ITA GTR)			
	VL0006	VL0612	VL1218	TOTAL
2004		43131	780	43911
2005		42636	673	43309
2006	21882	24188		46069
2007	12346	31257		43602
2008	18190	36918		55107
2009	18593	35777	29	54399
2010	19410	45377		64787
2011	24401	42102	355	66859
2012	15742	46892		62634
2013	2144	27227	461	29832
2014	13347	34080		47427
2015	5779	22866		28645
2016	6354	23620		29974
2017	15260	25688	1271	42219

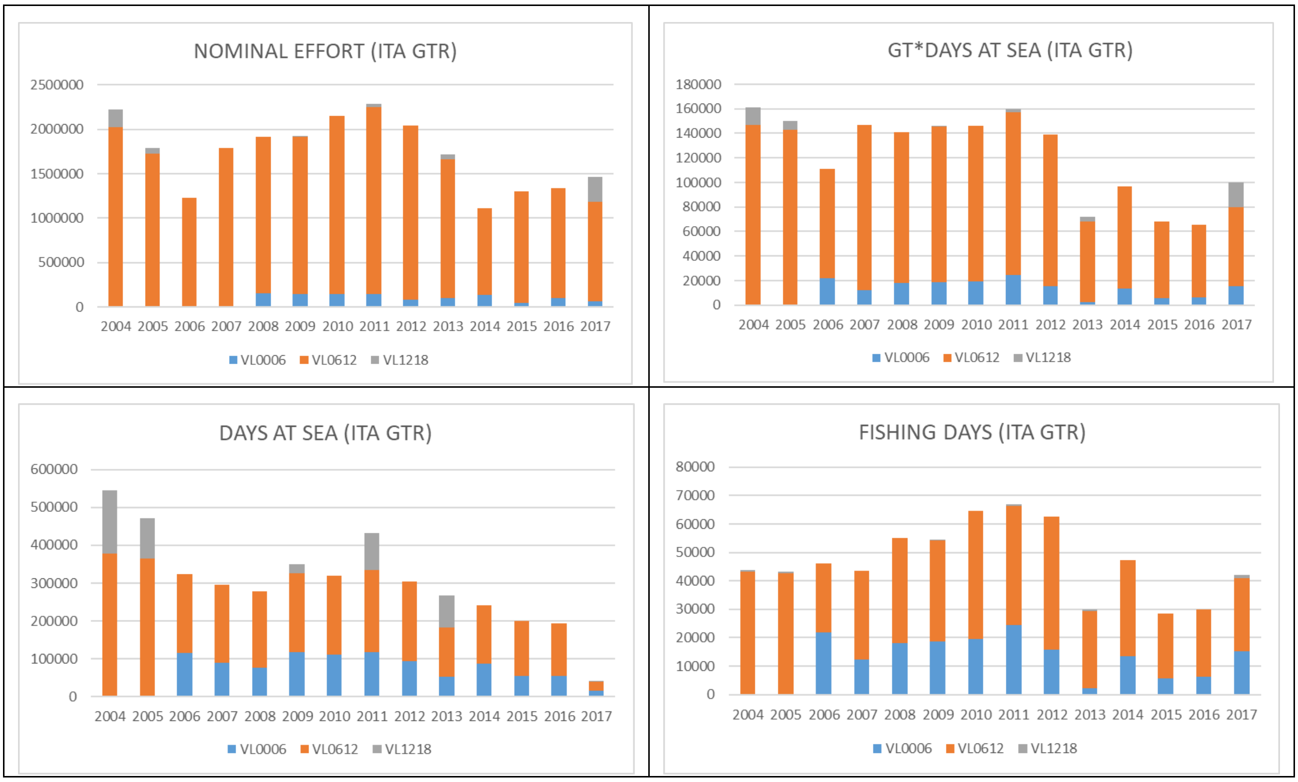


Figure 2.3.1. Trend of the GTR fishing effort in Italy

GILL-NETS (GNS)

Table 2.3.4. Detailed information on fishing effort of Italian gill-nets fleet by fleet segments

	NOMINAL EFFORT (ITA GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2004		5857477	76179		5933656
2005		6972817	36315	7273	7016405
2006	950819	5116639	33855		6101313
2007	669557	3149775			3819332
2008	658696	2687357			3346053
2009	922360	3355929	207674		4485963
2010	1012824	2605986	347970		3966780
2011	956952	3743627	393688		5094267
2012	619590	5075457	14740		5709787
2013	468078	3229470	54563		3752111
2014	928752	2965025	178345		4072122
2015	399810	3386856	246285		4032951
2016	328982	4278851	86590		4694423
2017	137066	1718889	196205		2052160

	GT*DAYS AT SEA (ITA GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2004		307558	5671		313229
2005		353760	2989	569	357318
2006	60721	268853	3882		333456
2007	49817	177189			227006
2008	41563	144997			186560
2009	65570	173647	13848		253065
2010	60623	164588	22068		247279
2011	63465	193708	24145		281318
2012	48165	248873	737		297775
2013	53000	188440	5219		246659
2014	112533	135678	6844		255055
2015	36241	174332	7491		218064
2016	32821	232231	1950		267002
2017	28125	88180	14097		130402

	DAYS AT SEA (ITA GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2004		377877	180824		558701
2005		365656	88825	11427	465908
2006	115264	273485	44276		433025
2007	88662	207377			296039
2008	103023	288170			391193
2009	202139	339333	109514		650987
2010	169142	237951	106025		513117
2011	159130	249424	98367		506921
2012	127322	372160	91243		590725
2013	79626	161925	65452		307003
2014	86992	153641	91302		331935
2015	58085	145426	80501		284012
2016	55711	171875	92550		320136
2017	28128	31593	889		60610

	FISHING DAYS (ITA GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2004		121497	549		122046
2005		161636	341	97	162073
2006	60718	90649	336		151703
2007	49815	71711			121526
2008	41563	70135			111699
2009	65571	79443	985		145999
2010	60627	67458	1558		129642
2011	63461	77039	1855		142355
2012	48164	74780	67		123011
2013	52688	76524	639		129851
2014	48075	50300	975		99350
2015	36239	63880	1238		101357
2016	32810	70626	488		103923
2017	28304	31939	889		61132

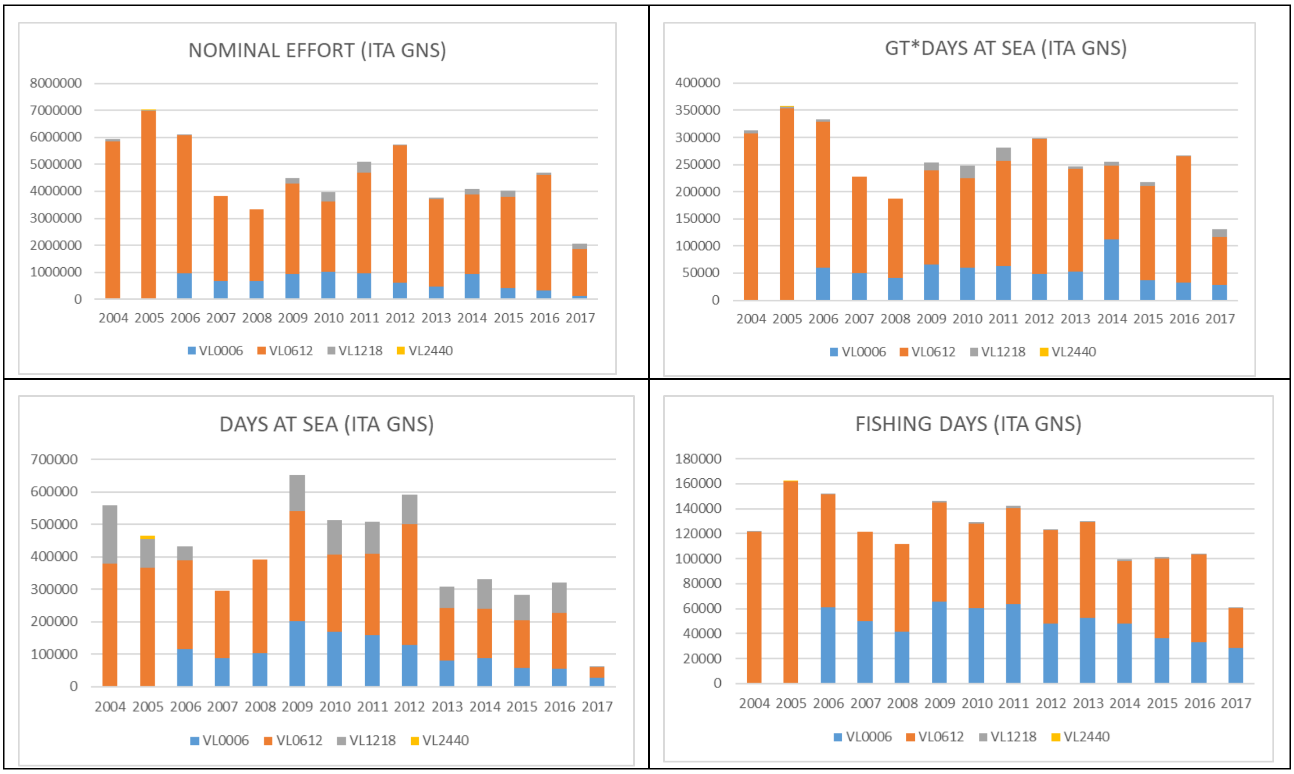


Figure 2.3.2. Trend of the GNS fishing effort in Italy

BEAM TRAWL (TBB)

Table 2.3.5. Detailed information on fishing effort of Italian beam trawl fleet by fleet segments

	DAYS AT SEA (ITA TBB)				
	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		142675	62886	26371	231932
2005		123048	61717	24737	209502
2006	37248	121111	56625	22041	237025
2007		126039	54178	20103	200320
2008		114969	36278	23255	174502
2009	122455	109514	38048	21964	291981
2010	112076	106025	36008	21041	275150
2011	163816	98367	33622	17683	313488
2012		91243	33665	18073	142981
2013		85574	31709	15100	132383
2014		91302	31229	16645	139175
2015	45333	80501	36176	12878	174888
2016		92550	34623	13877	141050
2017	327	1297	5653	2089	9366

	FISHING DAYS (ITA TBB)				
	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		2693	9716	2894	15302
2005		1293	8136	2288	11717
2006	95	1911	10267	3151	15424
2007		4080	12611	3585	20276
2008		2455	5404	4568	12427
2009	429	2967	4821	6072	14289
2010	258	2906	4128	4683	11974
2011	290	734	3846	3454	8324
2012		2008	4595	3536	10140
2013		1748	4298	1815	7860
2014		2365	6024	2377	10767
2015	306	1771	6169	1650	9897
2016		1985	5120	1896	9001
2017	329	1296	5655	2089	9369

	NOMINAL EFFORT (ITA TBB)				
	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		334153	2805025	1093359	4232537
2005	6725	222508	2775540	814867	3819640
2006		495531	3181976	1262005	4939512
2007		735007	3054938	1441889	5231834
2008	22738	555613	1753388	1827345	4159084
2009	13661	654533	1483127	2225756	4377077
2010	15391	610623	1302735	1890472	3819221
2011		198852	1125519	1244955	2569326
2012		462222	1318726	1473239	3254187
2013		388908	1807826	572941	2769675
2014	16232	472648	2454674	802493	3746047
2015		363071	2538081	530778	3431930
2016	27592,11	411064	2314917	581502	3335075
2017		238615	2349409	713007	3301031

	GT*DAYS AT SEA (ITA TBB)				
	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		46153	692134	264842	1003129
2005		38671	565485	181433	785589
2006	508	56658	679757	315989	1052912
2007		92744	640051	363569	1096364
2008		70835	325029	447877	843741
2009	1716	90811	300092	652584	1045203
2010	1033	90469	257797	571859	921158
2011	1162	23452	225761	414780	665155
2012		56022	273005	443679	772706
2013		53999	378745	224812	657556
2014		72739	549306	270550	892595
2015	1225	47973	548479	232662	830339
2016		54199	541012	236889	832100
2017	1440	34963	466930	190878	694210

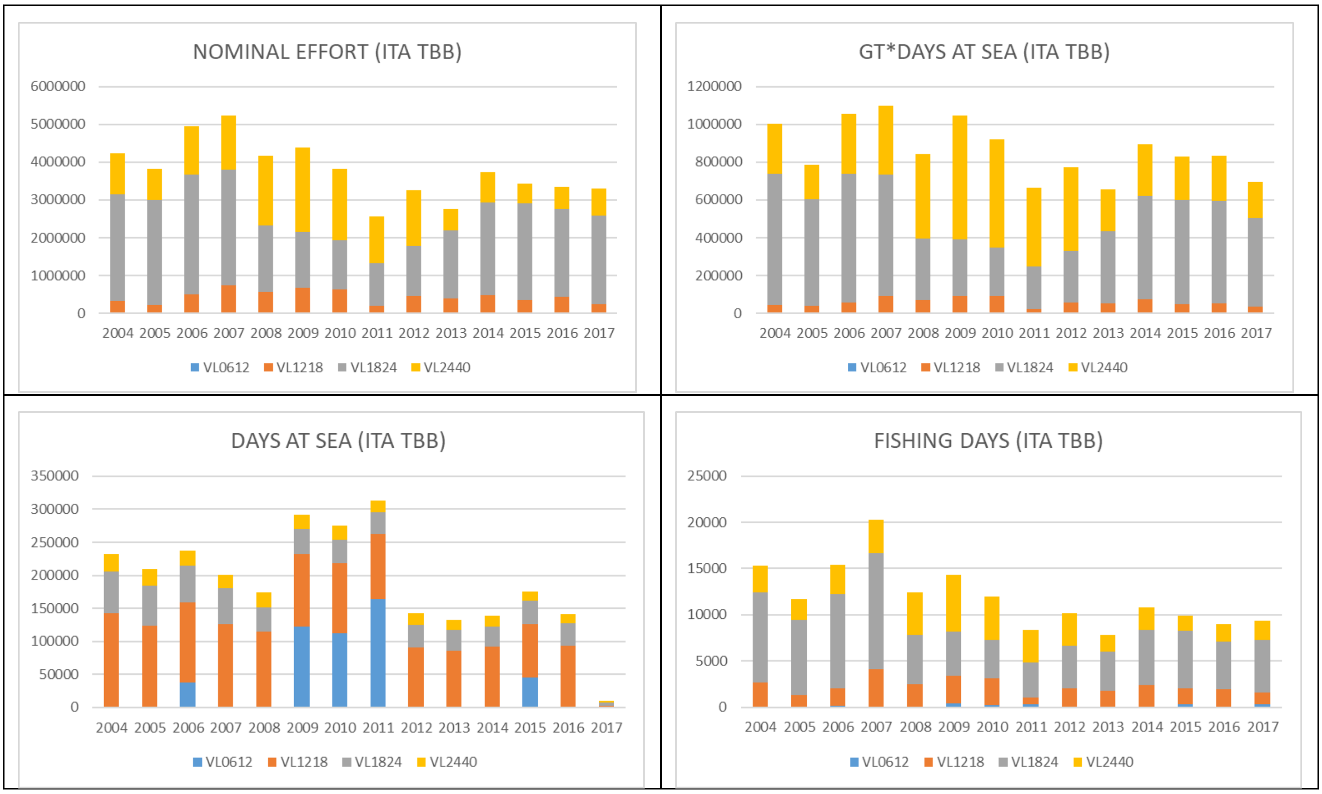


Figure 2.3.3. Trend of the TBB fishing effort in Italy

LONG LINES (LLS)

Table 2.3.6. Detailed information on fishing effort of Italian long lines fleet by fleet segments

	NOMINAL EFFORT (ITA LLS)			
	VL0006	VL0612	VL1218	TOTAL
2004		135486	461442	596928
2005		657182	396886	1054068
2006	4644	221152	547055	772851
2007	736	182478	451029	634243
2008	8056	106754	1145894	1260704
2009	330	272708	611112	884150
2010	720	213072	1050075	1263867
2011	1770	248331	672841	922942
2012	0	413737	554204	967941
2013		63467	389346	452813
2014			297350	297350
2015			547767	547767
2016		14209	528362	542571
2017		22892	707262	730153

	GT*DAYS AT SEA (ITA LLS)			
	VL0006	VL0612	VL1218	TOTAL
2004		10970	52822	63792
2005		41817	36089	77906
2006	6923	23621	47249	77793
2007	6843	21777	40557	69177
2008	5310	10214	92387	107911
2009	6496	16038	42407	64941
2010	6107	14122	67245	87474
2011	6143	15965	54404	76512
2012	9013	28671	35762	73446
2013		2158	30659	32817
2014			38728	38728
2015			56854	56854
2016		1320	54673	55993
2017		1136	72250	73385

	DAYS AT SEA (ITA LLS)			
	VL0006	VL0612	VL1218	TOTAL
2004		70899	57166	128065
2005		86016	60228	146243
2006	37120	140653	66724	244497
2007	26491	126392	57166	210049
2008	28874	52632	53852	135357
2009	32817	54716	70107	157640
2010	31722	57218	59411	148351
2011	35067	52168	57845	145079
2012	27773	48697	50036	126505
2013		44731	52125	96857
2014			43027	43027
2015			43457	43457
2016		80867	48582	129449
2017		393	3093	3487

	FISHING DAYS (ITA LLS)			
	VL0006	VL0612	VL1218	TOTAL
2004		5138	3123	8261
2005		15328	3198	18526
2006	6924	9790	3532	20246
2007	6841	6933	3792	17567
2008	5311	3967	4430	13707
2009	6494	5268	2539	14302
2010	6106	4956	4641	15703
2011	6145	4971	3846	14962
2012	9014	6715	2316	18044
2013		540	1645	2185
2014			2985	2985
2015			4365	4365
2016		440	4208	4647
2017		397	3095	3492

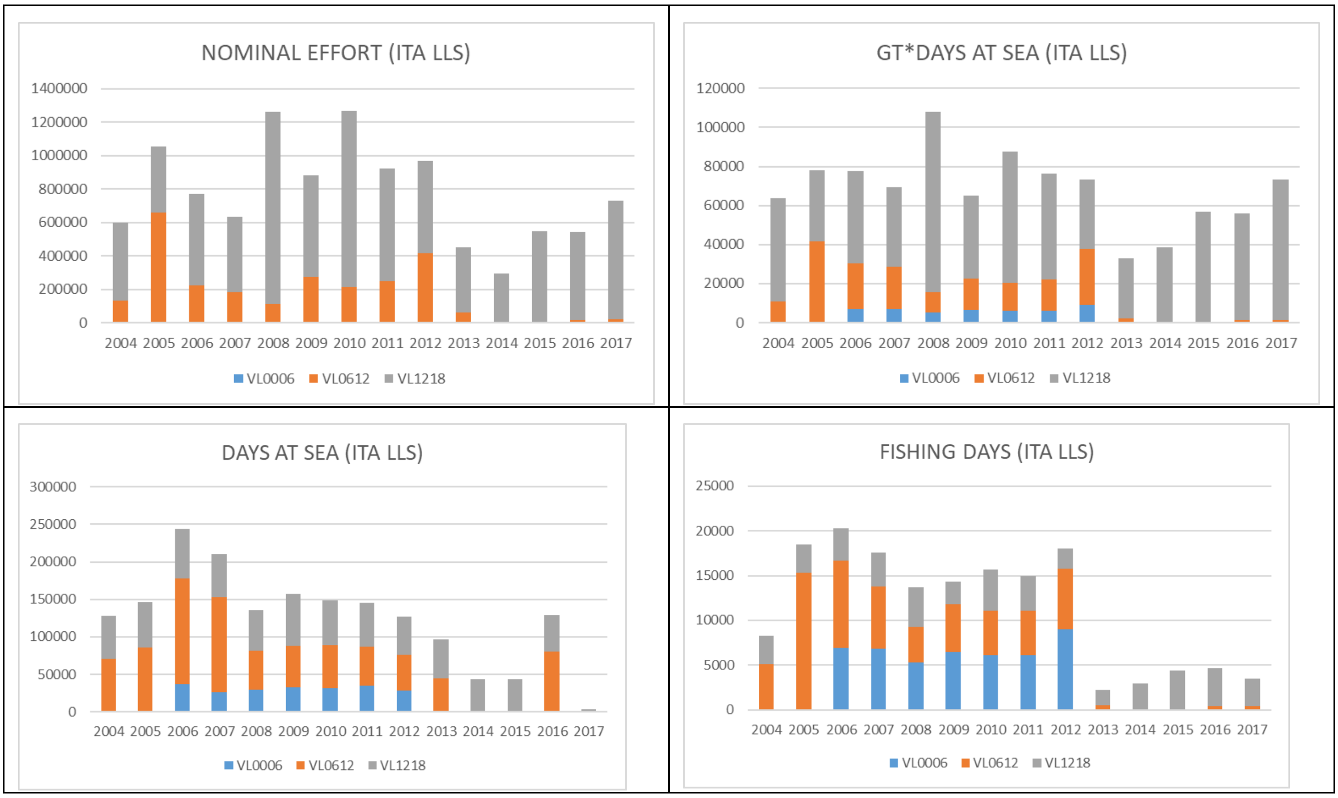


Figure 2.3.4. Trend of the LLS fishing effort in Italy

BOTTOM TRAWL (OTB)

Table 2.3.7. Detailed information on fishing effort of Italian bottom trawl fleet by fleet segments

	NOMINAL EFFORT (ITA OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		3027902	14945648	15080620	9221143	42275313
2005		1078187	15397385	13519329	7649591	37644492
2006	2123	1111442	15143266	13151811	5232779	34641421
2007		963567	13142495	13176967	4966222	32249251
2008		1232297	13963690	11078534	5227692	31502213
2009		1157298	15074029	11381433	5155598	32768358
2010		913216	12834080	11219817	4983725	29950838
2011		816243	12169373	10954703	3961217	27901536
2012		738609	10500292	9792457	2811363	23842721
2013	11060	859175	11307042	8797522	2151151	23125950
2014		1048994	9567755	8755156	2799442	22171347
2015		432405	8663204	9653778	2112173	20861560
2016		462642	8962888	10146583	2446321	22018434
2017		625031,7	12000792	12264058	3016412	27906294

	GT*DAYS AT SEA (ITA OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		175490	2005112	3227270	2427864	7835736
2005		98888	2084835	3271095	2065150	7519968
2006	61	88456	2121725	3050623	1480983	6741848
2007		71908	1883802	3067002	1328304	6351016
2008		93210	2074605	2615048	1339024	6121887
2009		89964	2122286	2708738	1296042	6217030
2010		70426	1914389	2673152	1247523	5905490
2011		66469	1745548	2566322	1004515	5382854
2012		63488	1604432	2426900	704572	4799392
2013	752	67109	1815170	2143719	613520	4640270
2014		64195	1512153	1994773	728704	4299825
2015		35693	1340832	2227644	623252	4227421
2016		35622	1353997	2367533	686145	4443297
2017		41941	1759969	2719225	775291	5296426

	DAYS AT SEA (ITA OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		448776	317524	145853	74356	986509
2005		365656	246774	127126	62009	801565
2006	46738	223021	219668	93010	53897	636334
2007		207377	210192	83037	58232	558838
2008		202934	248937	71795	84420	608086
2009		208321	319835	68016	65334	661505
2010		208234	284258	73754	56405	622651
2011		215984	214056	67979	57991	556011
2012		210429	164754	56669	48726	480577
2013	31458	161925	137699	79110	25839	436031
2014		153641	166995	51593	44574	416803
2015		145426	160177	82564	31884	420050
2016		143572	180378	68994	26282	419226
2017		10503	66335	40975	7708	125522

	FISHING DAYS (ITA OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2004		44672	111745	54362	17119	227898
2005		14856	109785	53475	20767	198883
2006	61	13616	108778	51617	14147	188218
2007		10193	91243	50275	12764	164475
2008		12541	92084	41827	13216	159668
2009		13331	105201	43080	12939	174551
2010		10804	88530	41539	11863	152736
2011		9326	82864	39239	10000	141429
2012		9502	70997	36253	6812	123564
2013	752	10781	81581	34422	5889	133424
2014		10367	66702	31228	7560	115857
2015		6257	64144	35356	6085	111841
2016		6399	67335	35401	6825	115960
2017		10584	66337	40975	7712	125608

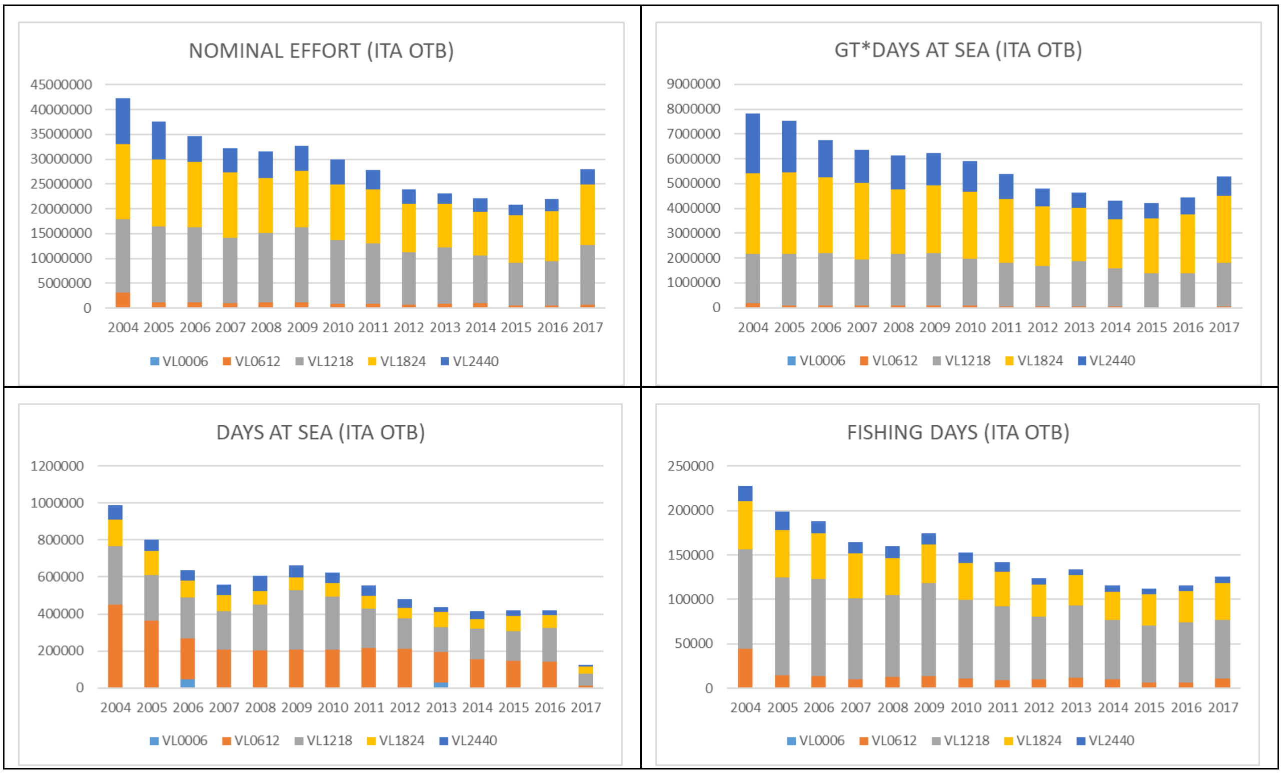


Figure 2.3.5. Trend of the OTB fishing effort in Italy

CROATIA

Following gears were chosen for analysis of effort of Croatian demersal fleet: OTB, LLS, DRB, GNS and GTR. As previously mention, TBB is not taken in to analysis due to fact that there is only one vessel operating in the year 2017, and FPO for Norway lobster because it is not possible to separate fishing effort coming from these traps from fishing effort coming from other traps targeting other demersal species.

BOTTOM TRAWL (OTB)

Table 2.3.8. Detailed information on fishing effort of Croatian bottom trawl fleet by fleet segments

	NOMINAL EFFORT (CRO OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	338	1204697	2854448	1342493	1476210	6878185
2013	353	1224447	2855103	1563544	1508104	7151551
2014	286	1338229	2855219	1595446	1502420	7291600
2015	3	1280633	2779410	1440961	1611688	7112694
2016	58	1248722	2723546	1637370	1185913	6795609
2017	377	1440364	2849434	1495671	1026052	6811898

	GT*DAYS AT SEA (CRO OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	30	109354	331965	315945	532042	1289335
2013	33	109873	337445	360354	565806	1373511
2014	17	120095	338369	369374	553715	1381570
2015	1	116437	337104	323560	569155	1346257
2016	2	112539	318565	423847	376833	1231785
2017	20	128510	340016	397575	303249	1169370

	DAYS AT SEA (CRO OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	27	11926	18684	5430	3062	39128
2013	32	11315	18524	6125	3230	39226
2014	11	12428	18695	6157	3262	40553
2015	1	11977	18284	5355	3457	39074
2016	2	11435	17784	5486	2495	37201
2017	19	12708	18276	4927	2201	38131

	FISHING DAYS (CRO OTB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	24	10846	17167	4694	2840	35572
2013	31	10302	16849	5323	2987	35492
2014	8	11251	16822	5278	2928	36287
2015	1	10853	16540	4332	3017	34742
2016	1	10325	16257	4881	2252	33715
2017	15	11826	17165	4584	2059	35649

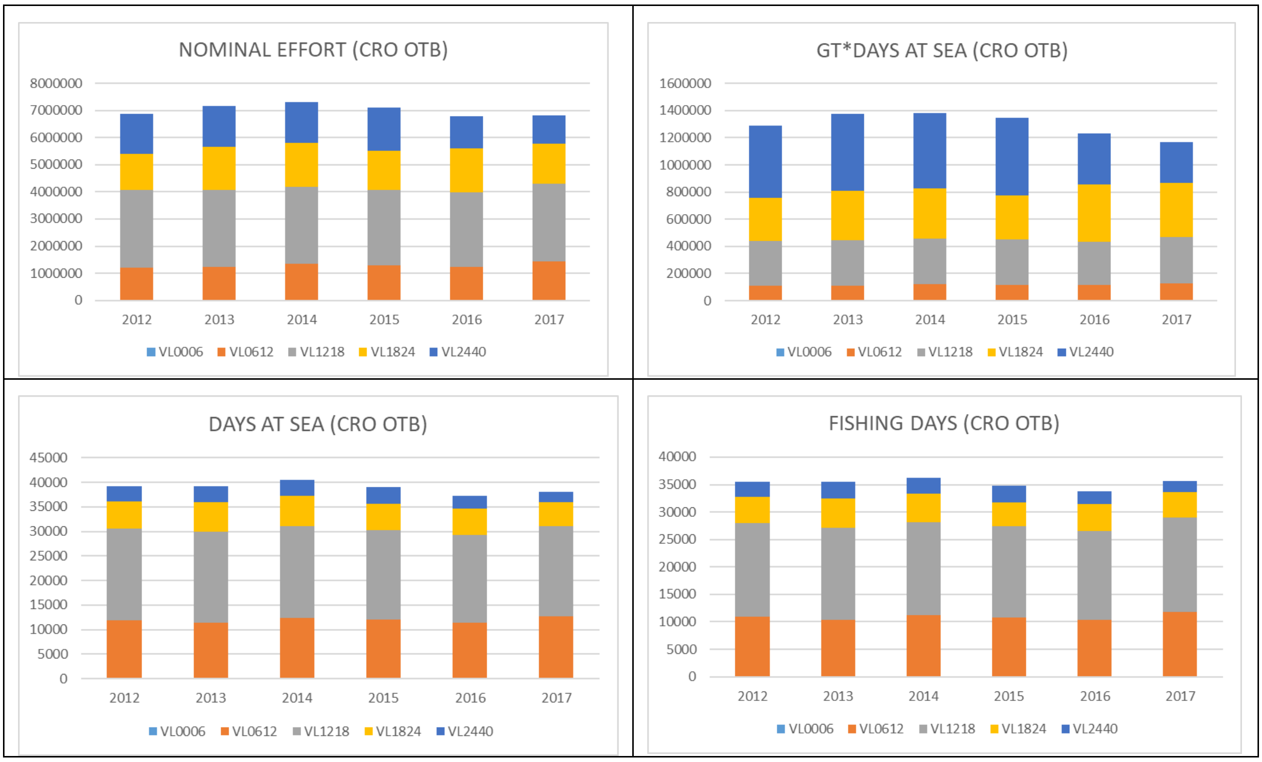


Figure 2.3.6. Trend of the OTB fishing effort in Croatia

Gill nets (GNS)

Table 2.3.9. Detailed information on fishing effort of Croatian gill net fleet by fleet segments

	NOMINAL EFFORT (CRO GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2012	220530	2250308	81526	3573	2555937
2013	221619	1994144	97940		2313703
2014	218100	2200014	67269		2485382
2015	228550	2099896	41801		2370247
2016	242862	1987339	42722	10182	2283105
2017	246478	1984414	65539		2296431

	GT*DAYS AT SEA (CRO GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2012	19828	133286	7483	1078	161675
2013	19018	119159	7986		146164
2014	19067	124691	6669		150427
2015	19834	120311	4222		144366
2016	21060	115652	4713	3689	145114
2017	21722	116503	5447		143673

	DAYS AT SEA (CRO GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2012	17806	42089	625	10	60530
2013	17278	38095	643		56016
2014	17842	39012	557		57411
2015	18147	38151	397		56695
2016	20259	35888	463	19	56630
2017	20711	37395	516		58622

	FISHING DAYS (CRO GNS)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2012	13704	33406	544	8	47661
2013	13077	29704	522		43304
2014	13689	31018	462		45170
2015	14033	29951	361		44346
2016	15070	27861	378	14	43324
2017	15364	28747	413		44524

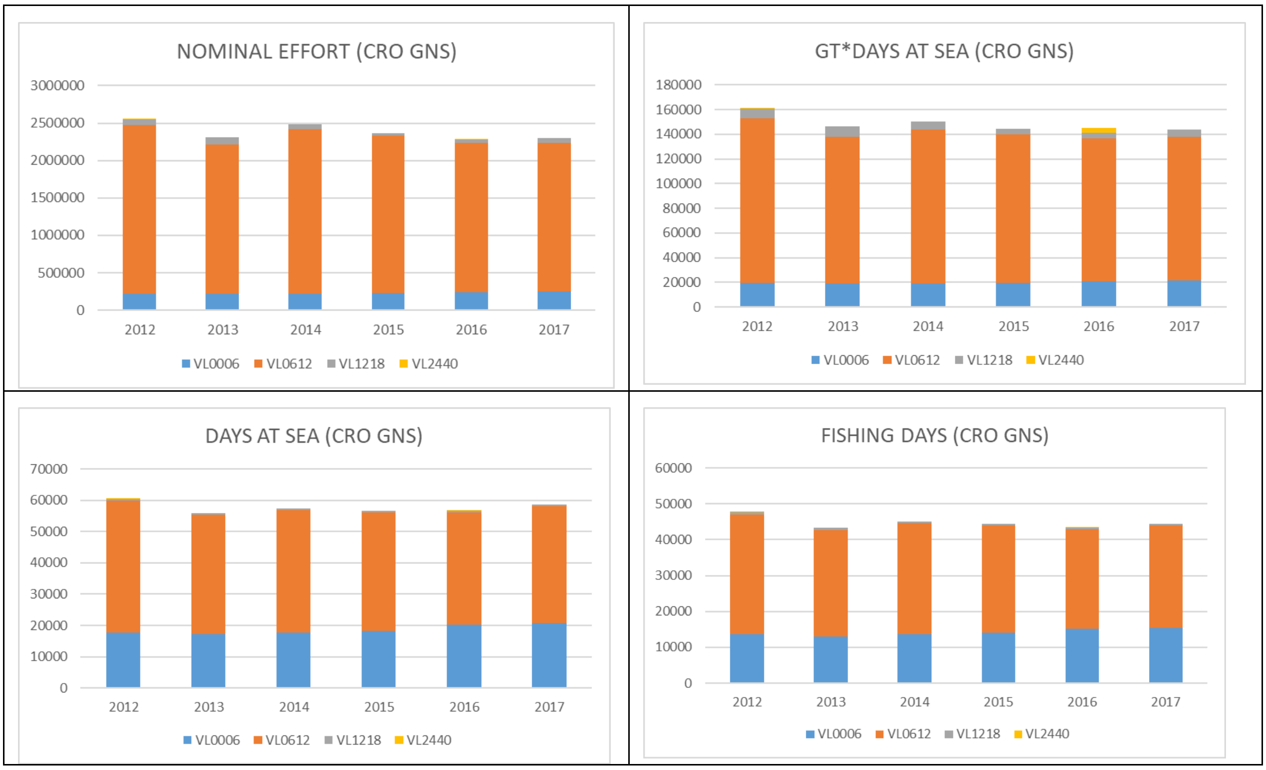


Figure 2.3.7. Trend of the GNS fishing effort in Croatia

TRAMELL NET (GTR)

Table 2.3.10. Detailed information on fishing effort of Italian trammel net fleet by fleet segments

	NOMINAL EFFORT (CRO GTR)				
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2013	103790	1844045	234860		5995	2188689
2013	92953	2032623	198242	585		2324403
2014	113466	1818970	152237			2084672
2015	97344	2017308	198043			2312695
2016	98428	1761354	98836		1495	1960112
2017	99339	1846409	156863			2102611

	GT*DAYS AT SEA (CRO GTR)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2013	9670	100997	15783		1808	128258
2013	7668	108310	12532	166		128677
2014	9256	96511	10947			116713
2015	8419	105469	14139			128027
2016	7763	92342	8548		541	109194
2017	7241	94252	10923			112415

	DAYS AT SEA (CRO GTR)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2013	8990	26244	1140		16	36391
2013	7212	27605	917	3		35736
2014	8872	25225	763			34860
2015	8229	26888	1015			36132
2016	7504	24318	601		3	32426
2017	7157	24057	814			32028

	FISHING DAYS (CRO GTR)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2013	7032	20483	995		12	28522
2013	5764	21520	787	3		28074
2014	6999	19527	575			27101
2015	6383	21387	915			28685
2016	5691	19112	550		3	25356
2017	5508	18820	747			25075

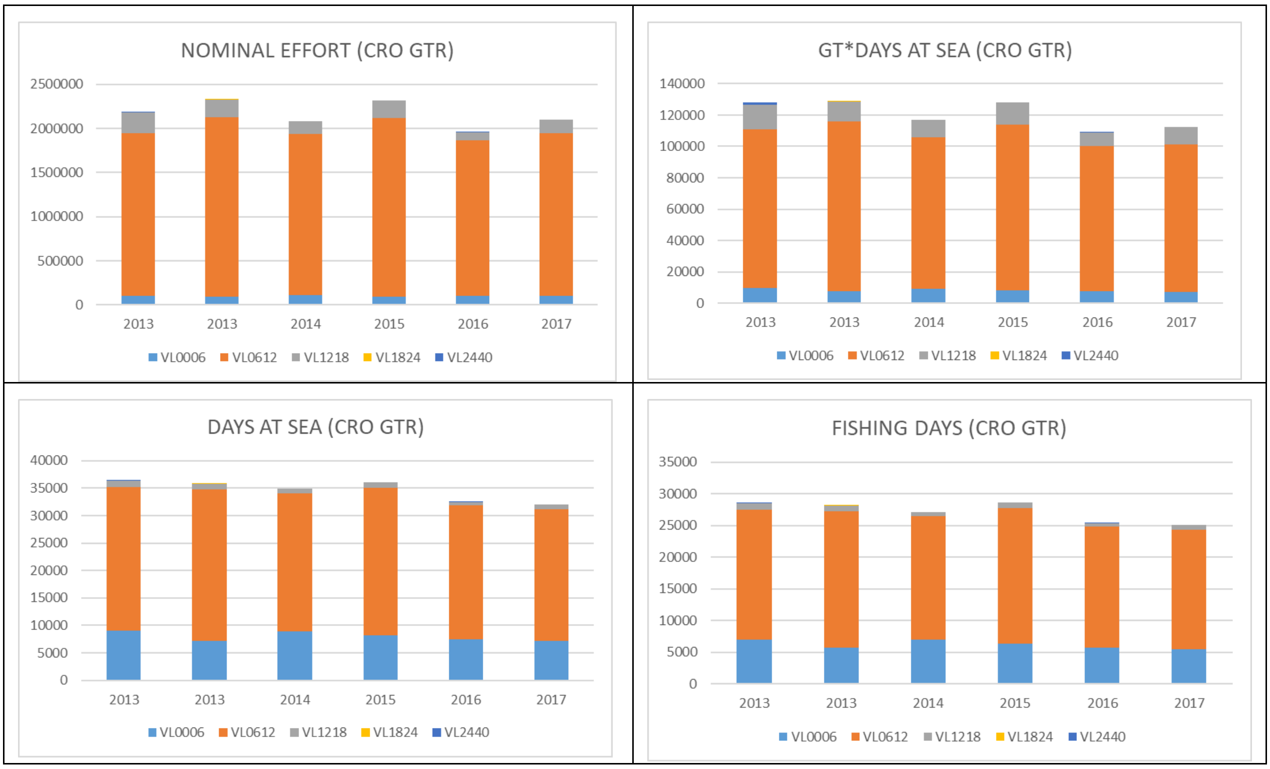


Figure 2.3.8. Trend of the GTR fishing effort in Croatia

DREDGE "RAMPON" (DRB)

Table 2.3.11. Detailed information on fishing effort of Croatian dredge fleet by fleet segments

	NOMINAL EFFORT (CRO DRB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012		102549	153399	391	1180	257518
2013		140891	254396	49248	662	445197
2014	13	180016	373125	44337		597491
2015		226586	602510	36946	17212	883255
2016		225425	581405	37179	7202	851212
2017		177443	559685	31272		768400

	GT*DAYS AT SEA (CRO DRB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012		7309	13471	89		20869
2013		10400	20974	10339	246	41958
2014	1	13089	30708	9384	170	53352
2015		17085	51608	8397		77090
2016		15472	47698	8450	4420	76040
2017		12925	46605	7107	1821	68459

	DAYS AT SEA (CRO DRB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012		965	960	2	2	1929
2013		1231	1541	191	2	2964
2014	1	1560	2240	187		3989
2015		1788	3522	153		5463
2016		1629	3368	154	52	5203
2017		1428	3257	129	21	4835

	FISHING DAYS (CRO DRB)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012		962	920	2	2	1885
2013		1201	1503	161	1	2865
2014	1	1530	2176	177		3882
2015		1758	3392	153		5303
2016		1599	3258	154	50	5061
2017		1331	2977	125	20	4453

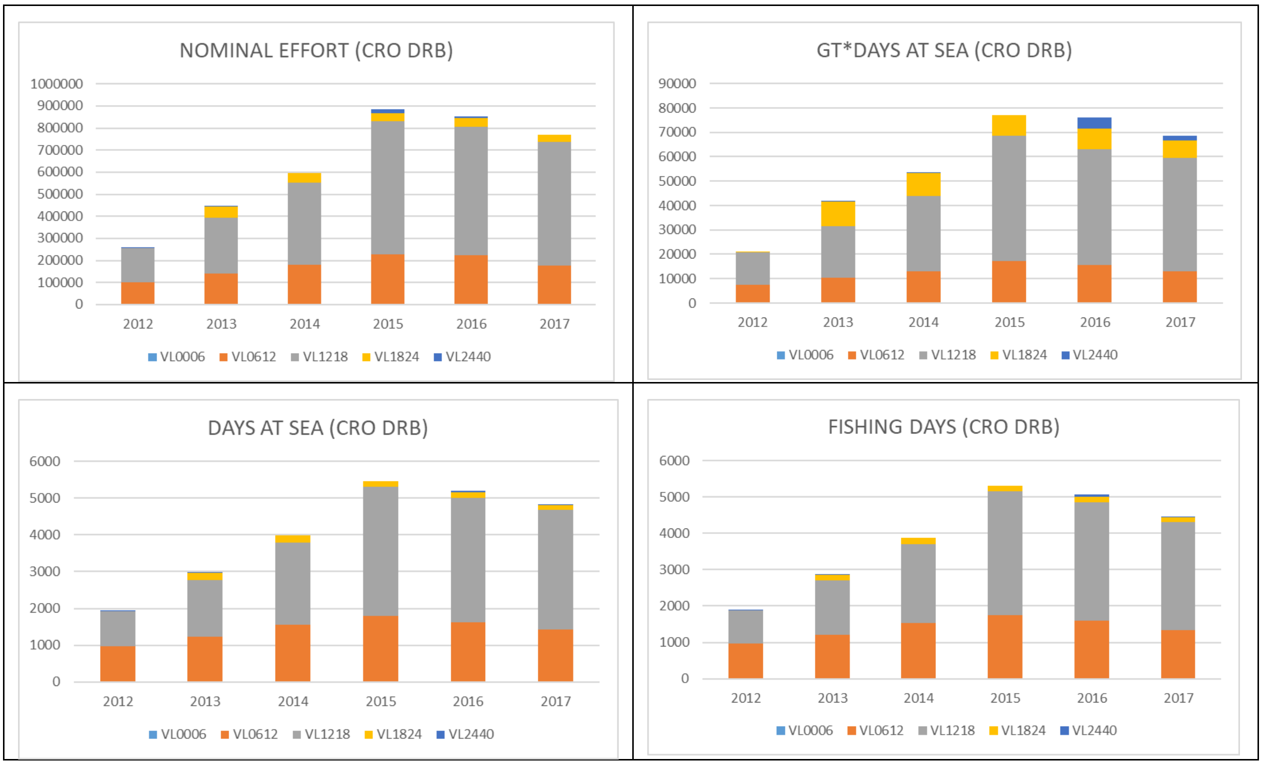


Figure 2.3.9. Trend of the DRB fishing effort in Croatia

BOTTOM LONG LINES (LLS)

Table 2.3.12. Detailed information on fishing effort of Croatian bottom long lines fleet by fleet segments

	NOMINAL EFFORT (CRO LLS)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	48720	714414	47558			810693
2013	62992	816920	26400			906311
2014	46970	793177	34398	1278		875824
2015	44922	723980	22147	1864		792914
2016	36598	602141	9455		513	648707
2017	36208	752932	3543			792684

	GT*DAYS AT SEA (CRO LLS)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	2892	36465	1710			41067
2013	3364	39754	831			43949
2014	3122	39888	1275	297		44581
2015	2962	37718	995	340		42016
2016	2147	33455	460		186	36247
2017	2385	38973	132			41489

	DAYS AT SEA (CRO LLS)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	2593	10074	112			12780
2013	3137	10058	52			13247
2014	2850	10040	52	9		12952
2015	2664	9800	57	10		12532
2016	2146	9039	29		1	11215
2017	2325	10247	5			12577

	FISHING DAYS (CRO LLS)					
	VL0006	VL0612	VL1218	VL1824	VL2440	TOTAL
2012	2085	7041	104			9229
2013	2448	7216	49			9713
2014	2143	7080	47	7		9277
2015	2017	6931	53	9		9010
2016	1638	6600	25		1	8264
2017	1716	7103	4			8823

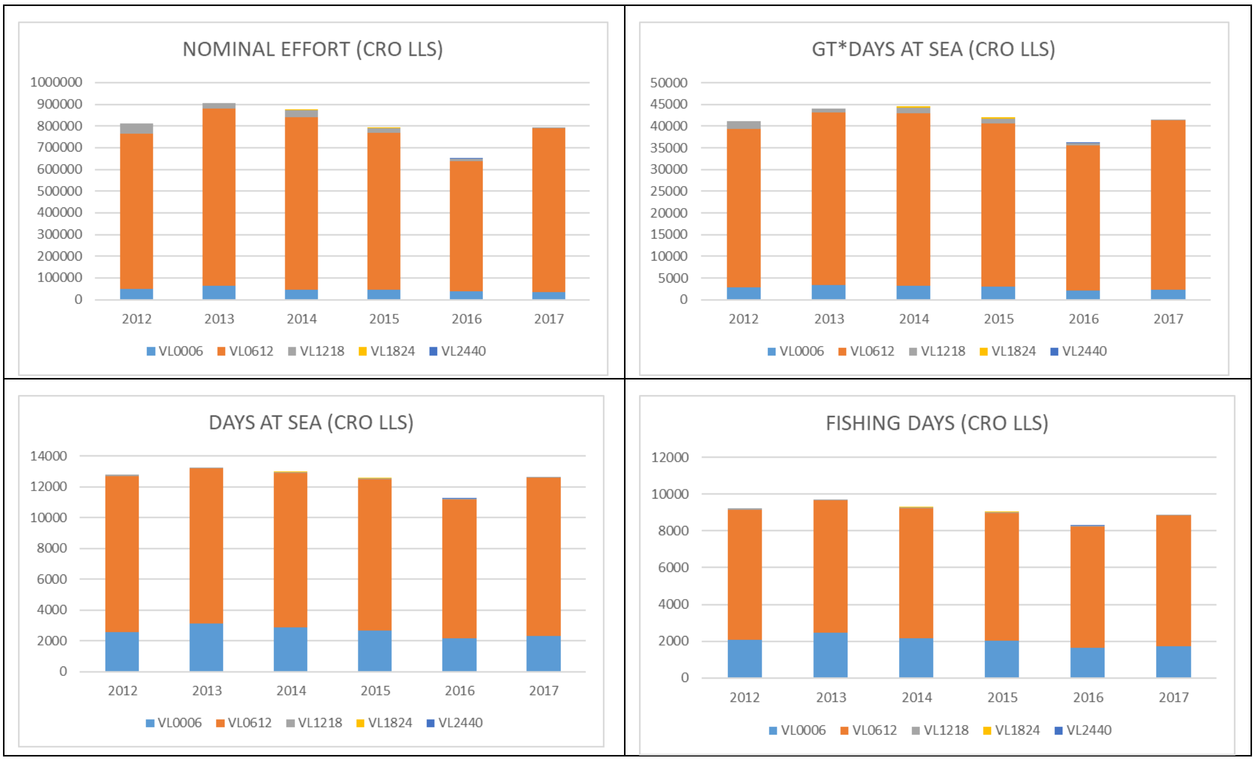


Figure 2.3.10. Trend of the LLS fishing effort in Croatia

SLOVENIA

The effort for following Slovenian fishing fleets were analysed: OTB, GNS and GTR. Fishing gears DRB, TBB and FPO for Norway lobster don’t exist in Slovenia, while LLS are not used in catch of hake because this species is caught only sporadically in Slovenia.

BOTTOM TRAWL (OTB)

Table 2.3.13. Detailed information on fishing effort of Slovenian bottom trawl fleet by fleet segments

	NOMINAL EFFORT (SVN OTB)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2005	26	36289	76348		112663
2006		38712	104814		143526
2007		37602	145176	1200	183978
2008		38130	158851	1200	198181
2009		34311	166569		200880
2010		44817	163045		207862
2011		36637	151984		188621
2012		19851	133795		153646
2013		18065	95629		113694
2014		19253	80594		99847
2015		17882	83594		101476
2016		15256	95715		110971
2017		21393	86027		107421

	GT*DAYS AT SEA (SVN OTB)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2005	4	2069	7083		9155
2006		2163	10128		12291
2007		2210	14891		17101
2008		2248	16298	312	18858
2009		1771	16421	312	18504
2010		2288	15947		18235
2011		2209	15572		17782
2012		1039	14025		15063
2013		1066	10894		11960
2014		1263	8109		9372
2015		1004	8986		9990
2016		917	9618		10534
2017		1285	8930		10214

	DAYS AT SEA (SVN OTB)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2005	4	358	469		831
2006		356	607		963
2007		343	858	1	1202
2008		316	937	1	1254
2009		229	976		1205
2010		305	958		1263
2011		270	908		1178
2012		124	793		917
2013		157	609		766
2014		180	500		680
2015		159	537		696
2016		156	656		812
2017		194	503		697

	FISHING DAYS (SVN OTB)				
	VL0006	VL0612	VL1218	VL2440	TOTAL
2005	4	358	469		831
2006		356	607		963
2007		343	858	1	1202
2008		316	937	1	1254
2009		229	976		1205
2010		305	958		1263
2011		270	908		1178
2012		124	793		917
2013		157	609		766
2014		180	500		680
2015		159	537		696
2016		156	656		812
2017		194	503		697

Figure 2.3.11. Trend of the OTB fishing effort in Slovenia

TRAMMEL NET (GTR)

Table 2.3.14. Detailed information on fishing effort of Slovenian trammel net fleet by fleet segments

	NOMINAL EFFORT (SVN GTR)			
	VL0006	VL0612	VL1218	TOTAL
2005	4856	37223	19199	61277
2006	3458	50757		54215
2007	5290	106076	11550	122916
2008	9947	121790	6499	138236
2009	9211	90613	3552	103376
2010	10066	105500	12634	128200
2011	14002	155235	2527	171764
2012	27383	135820	3432	166635
2013	25147	154206	62433	241785
2014	27759	161531	5773	195063
2015	28273	149928	10053	188255
2016	23402	127823	9005	160231
2017	19305	101950	2259	123514

	GT*DAYS AT SEA (SVN GTR)			
	VL0006	VL0612	VL1218	TOTAL
2005	612	2074	360	3047
2006	588	2402		2990
2007	733	4837	1254	6824
2008	823	6127	719	7669
2009	820	4827	323	5970
2010	808	5718	1028	7554
2011	1029	7914	228	9171
2012	1540	6360	351	8251
2013	1523	7386	5933	14843
2014	1691	8411	442	10544
2015	1621	7553	1050	10224
2016	1088	6500	843	8431
2017	979	5423	190	6593

	DAYS AT SEA (SVN GTR)			
	VL0006	VL0612	VL1218	TOTAL
2005	636	641	36	1313
2006	674	589		1263
2007	764	1099	106	1969
2008	844	1550	64	2458
2009	868	1166	24	2058
2010	888	1428	72	2388
2011	1035	2028	17	3080
2012	1462	1533	30	3025
2013	1494	1827	490	3811
2014	1587	2333	35	3955
2015	1630	2137	89	3856
2016	1043	2085	68	3196
2017	966	1727	16	2709

	FISHING DAYS (SVN GTR)			
	VL0006	VL0612	VL1218	
2005	636	641	36	TOTAL
2006	674	589		1263
2007	764	1099	106	1969
2008	844	1550	64	2458
2009	868	1166	24	2058
2010	888	1428	72	2388
2011	1035	2028	17	3080
2012	1462	1533	30	3025
2013	1494	1827	490	3811
2014	1587	2333	35	3955
2015	1630	2137	89	3856
2016	1043	2085	68	3196
2017	1318	2117	18	3453

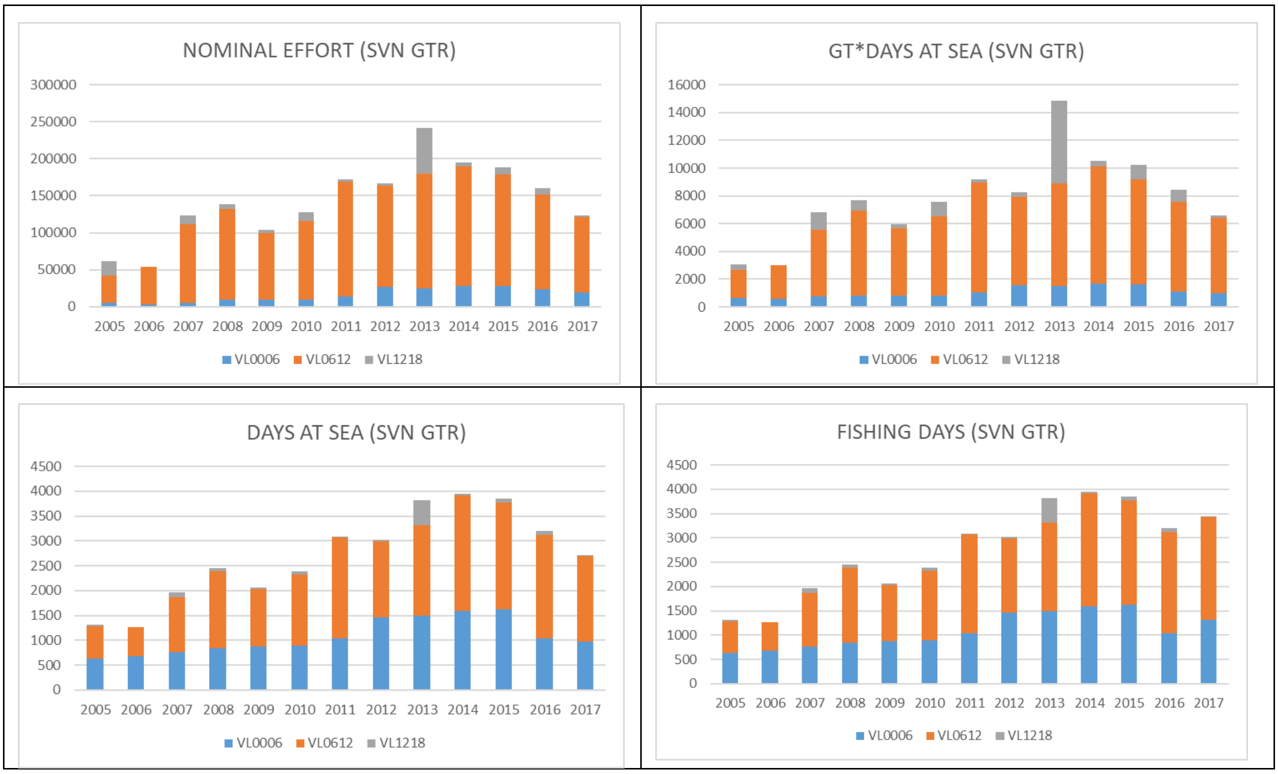


Figure 2.3.12. Trend of the GTR fishing effort in Slovenia

GILL NETS (GNS)

Table 2.3.15. Detailed information on fishing effort of Slovenian gill net fleet by fleet segments

	NOMINAL EFFORT (SVN GNS)			
	VL0006	VL0612	VL1218	TOTAL
2005	5736	26618	276	32630
2006	4650	30926	1470	37046
2007	6671	28118	18402	53191
2008	7936	62761	8910	79606
2009	9615	71814	2352	83781
2010	8117	92226	3243	103586
2011	8523	78380	6987	93889
2012	16987	117538	13486	148012
2013	17563	96074	5185	118821
2014	16347	91519	4550	112416
2015	26006	94177	3845	124028
2016	29319	82843	2471	114633
2017	27448	100726	4574	132748

	GR*DAYS AT SEA (SVN GNS)			
	VL0006	VL0612	VL1218	TOTAL
2005	821	1894	25	2740
2006	556	2124	164	2845
2007	821	2088	1801	4710
2008	755	3309	940	5004
2009	813	3537	263	4613
2010	635	4629	302	5566
2011	635	3992	667	5293
2012	1137	5420	1154	7711
2013	1017	4236	375	5627
2014	1183	4553	331	6066
2015	1221	4312	447	5980
2016	1298	3792	271	5360
2017	1063	4714	433	6211

	DAYS AT SEA (SVN GNS)			
	VL0006	VL0612	VL1218	TOTAL
2005	895	708	3	1606
2006	581	868	15	1464
2007	832	791	146	1769
2008	849	1092	84	2025
2009	871	979	24	1874
2010	691	1227	27	1945
2011	668	1079	56	1803
2012	1164	1521	96	2781
2013	1051	1212	32	2295
2014	1174	1474	28	2676
2015	1230	1340	38	2608
2016	1274	1352	23	2649
2017	1068	1704	36	2808

	FISHING DAYS (SVN GNS)			
	VL0006	VL0612	VL1218	TOTAL
2005	895	708	3	1606
2006	581	868	15	1464
2007	832	791	146	1769
2008	849	1092	84	2025
2009	871	979	24	1874
2010	691	1227	27	1945
2011	668	1079	56	1803
2012	1164	1521	96	2781
2013	1051	1212	32	2295
2014	1174	1474	28	2676
2015	1230	1340	38	2608
2016	1274	1352	23	2649
2017	1446	2236	45	3727

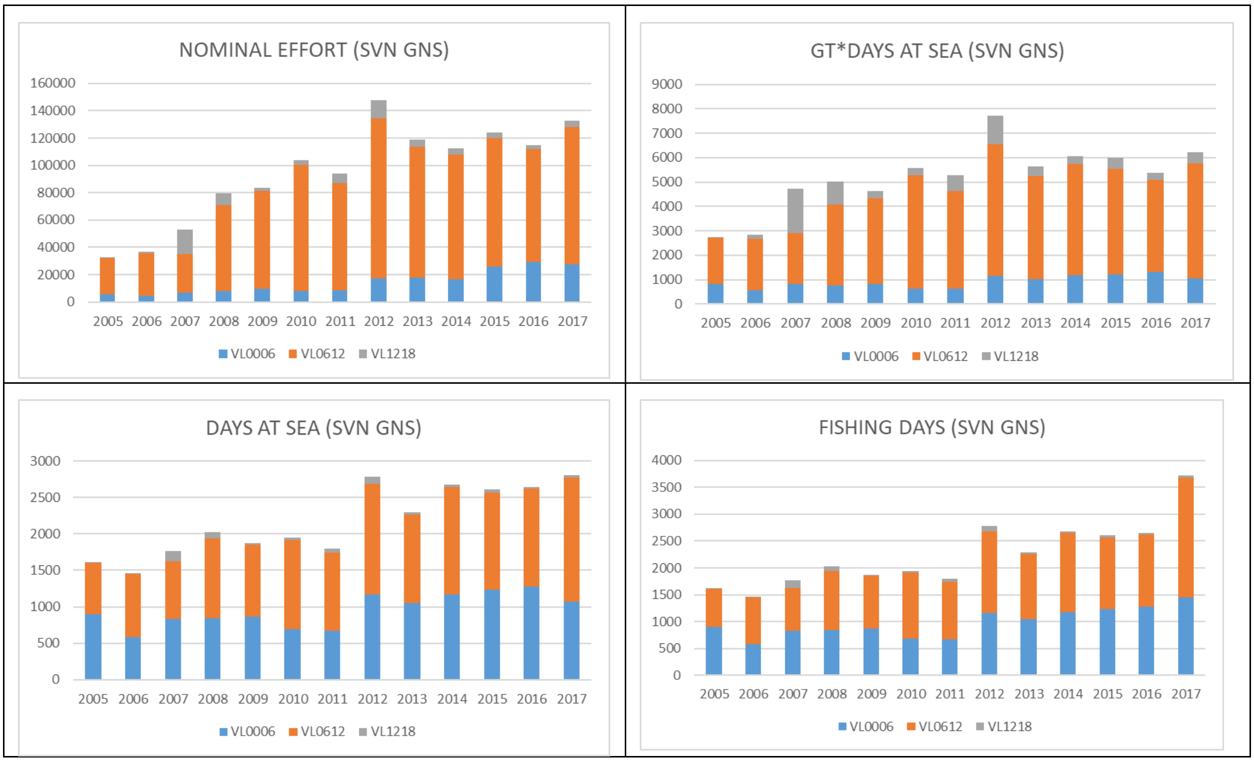


Figure 2.3.13. Trend of the GNS fishing effort in Slovenia

Analysis by fishing gear

Taking in mind that it is not possible to compare effort data for selected fishing gears using DCF data, for comparison Transversal data was taken. Namely, in the Italian DCF data nominal effort and GT*day at sea were calculated using fishing days instead days at sea, and also, there is a problem in the Italian data about days at sea: those data seem to be non-logical and probably wrong.

Transversal data on effort cover period from 2012 till 2017 for Croatia, and period from 2008 till 2016 for Italy and Slovenia

BOTTOM TRAWL OTB

Table 2.3.16. Effort data on OTB fisheries by countries

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CRO TOT FISH DAYS					34650	34848	36135	34735	33801	35590
CRO TOT GT FISH DAYS					1076239	1249624	1240530	1170718	1118202	1098657
CRO TOT KW FISH DAYS					6227277	6465090	6506687	6233938	6173919	6383392
ITA TOT FISH DAYS	159668	174551	152736	141429	123564	131425	115857	111841	115960	
ITA TOT GT FISH DAYS	6121887	6217030	5905490	5382854	4802256	4496619	4299825	4227325	4443297	
ITA TOT KW FISH DAYS	31502213	32768358	29950838	27901536	23842721	22383109	22171347	20860827	22018434	
SVN TOT FISH DAYS	1241	1208	1559	1188	997	871	797	826	923	744
SVN TOT GT FISH DAYS	18483	18238	23280	17909	15977	13611	10488	11436	11391	
SVN TOT KW FISH DAYS	195160	201023	258099	189176	164399	129369	118775	123942	128639	

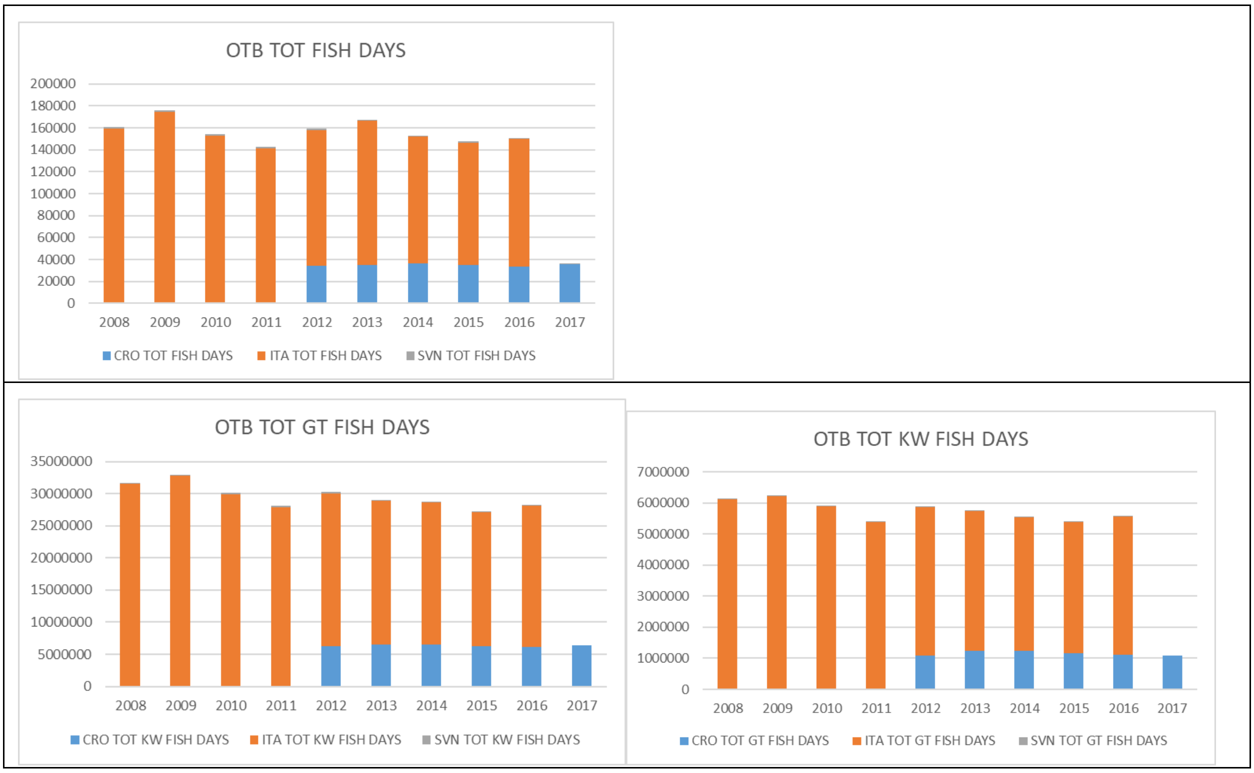


Figure 2.3.14. Trend of the OTB fishing effort by countries

GILL NETS

Table 2.3.17. Effort data on GNS fisheries by countries

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CRO TOT FISH DAYS					49611	46092	47642	47083	43525	44723
CRO TOT GT FISH DAYS					134617	124439	130136	124769	115672	116417
CRO TOT KW FISH DAYS					2152741	1981904	2188151	2104049	1937409	1930408
ITA TOT FISH DAYS	2008	2009	2010	2011	2012	2013	2014	2015	2016	
ITA TOT GT FISH DAYS	111699	145999	129642	142355	123011	129851	99350	101357	103923	
ITA TOT KW FISH DAYS	186560	253065	247279	281318	297775	246659	255055	218064	267002	
SVN TOT FISH DAYS	3346053	4485963	3966780	5094267	5709787	3752111	4072122	4032792	4694423	
SVN TOT GT FISH DAYS	2009	1882	2005	1778	2791	2559	2698	3160	3156	3064
SVN TOT KW FISH DAYS	4536	9734	5169	5063	7648	6152	6539	7413	7139	

Figure 2.3.15. Trend of the GNS fishing effort by countries

TRAMMEL NET (GTR)

Table 2.3.18. Effort data on GTR fisheries by countries

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CRO TOT FISH DAYS					25591	27138	24697	26031	22961	22499
CRO TOT GT FISH DAYS					99878	101372	88925	100839	84710	87203
CRO TOT KW FISH DAYS					1750913	1848744	1607281	1828264	1544931	1607524
ITA TOT FISH DAYS	55107	54399	64787	66859	62634	29340	47427	28644	29974	
ITA TOT GT FISH DAYS	140756	146020	146123	159577	138850	69280	96645	68138	65283	
ITA TOT KW FISH DAYS	1914906	1916843	2146768	2286656	2046945	1642202	1112850	1300287	1339287	
SVN TOT FISH DAYS	2212	2359	2398	3061	3022	3505	3956	3853	3294	2968
SVN TOT GT FISH DAYS	6268	7394	7538	9045	7922	11151	10973	10663	9333	
SVN TOT KW FISH DAYS	106055	127567	130610	194171	126516	202258	201736	200951	177276	

Figure 2.3.16. Trend of the GTR fishing effort by countries

BOTTOM LONG LINES (LLS)

Table 2.3.19. Effort data on LLS fisheries by countries

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CRO TOT FISH DAYS					9166	9645	9284	9080	8032	8557
CRO TOT GT FISH DAYS					29530	33083	33005	30942	25939	28244
CRO TOT KW FISH DAYS					591887	728477	678913	598537	457622	535820
ITA TOT FISH DAYS	13707	14302	15703	14962	18044	2184	2985	4365	4647	
ITA TOT GT FISH DAYS	107911	64941	87474	76512	73446	32817	38728	56854	55993	
ITA TOT KW FISH DAYS	1260704	884150	1263867	922942	967941	452813	297350	547746	542571	

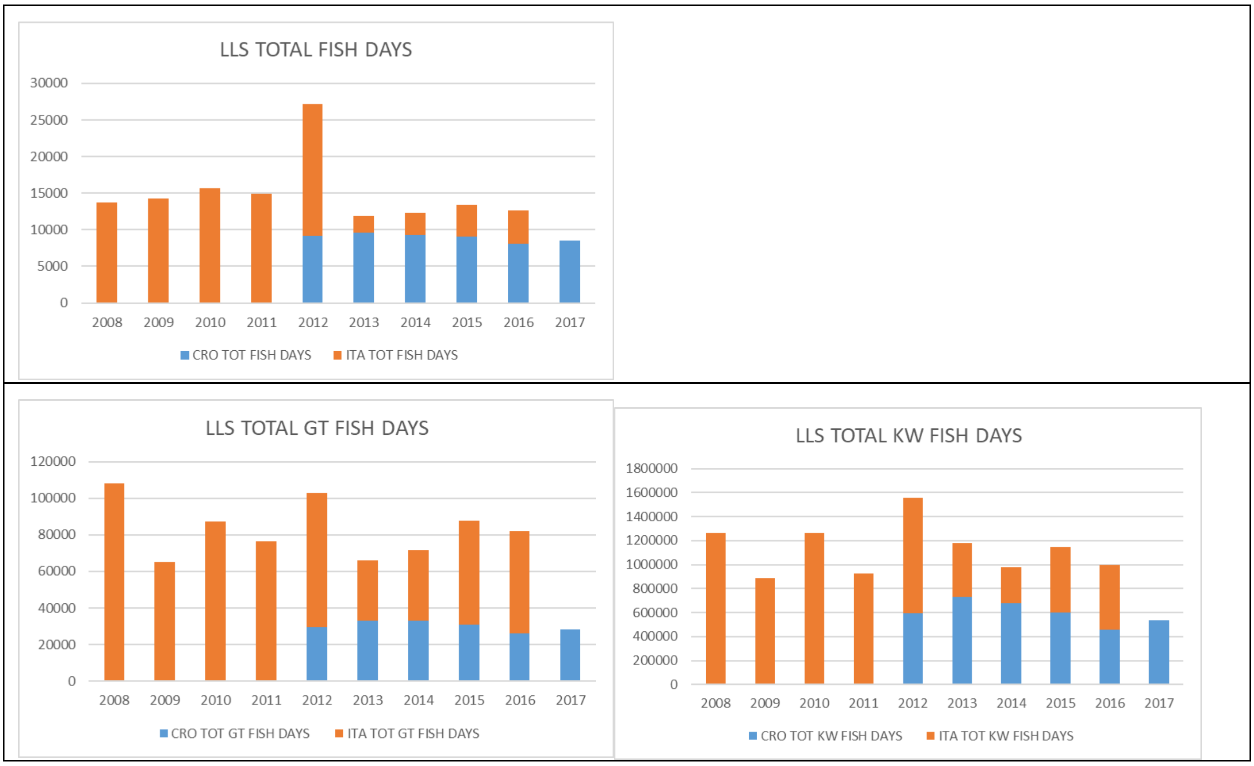


Figure 2.3.17. Trend of the LLS fishing effort by countries

DREDGE (DRB)

Table 2.3.20. Effort data on DRB fisheries Croatia

	2012	2013	2014	2015	2016	2017
CRO TOT FISH DAYS	1934	2857	3820	5227	5077	4477
CRO TOT GT FISH DAYS	21554	39416	50902	73332	74211	64409
CRO TOT KW FISH DAYS	260494	424881	572080	824335	840908	721923

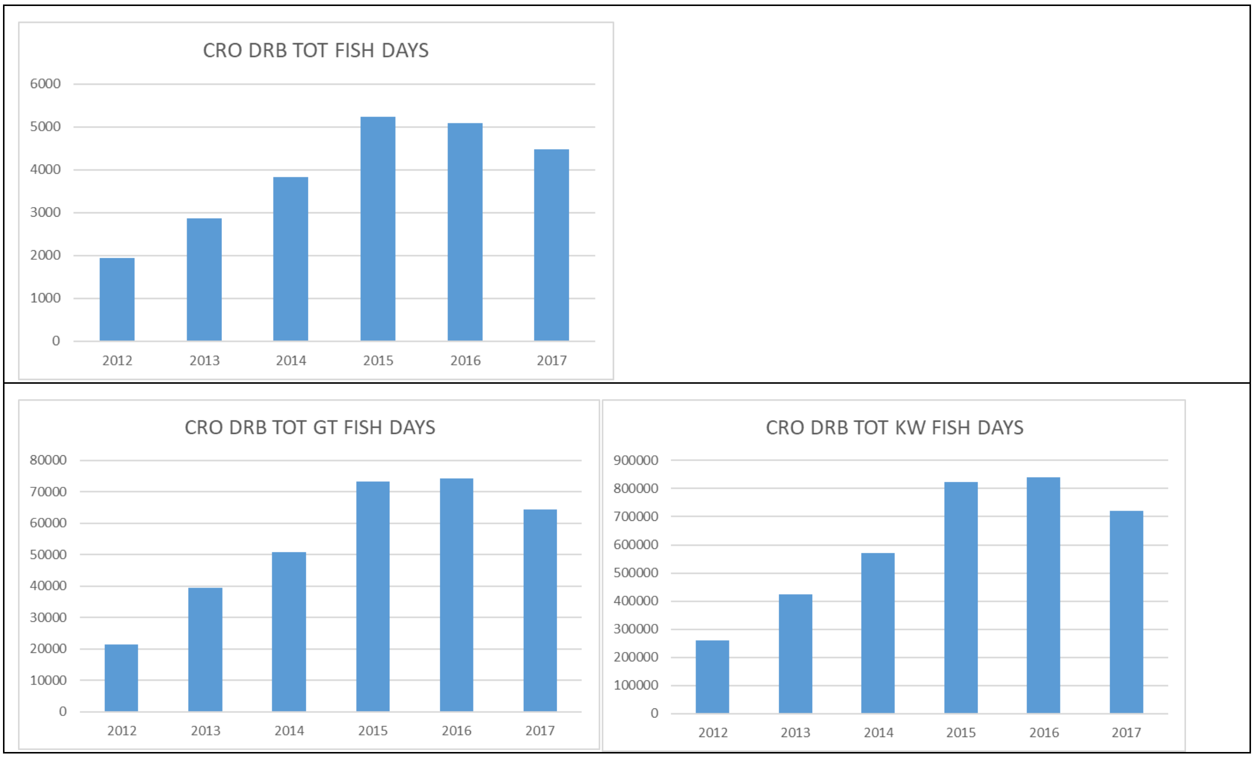


Figure 2.3.18. Trend of the DRB fishing effort in Croatia

BEAM TRAWL (TBB)

Table 2.3.21. Effort data on TBB fisheries by countries

	2008	2009	2010	2011	2012	2013	2014	2015	2016
ITA TOT FISH DAYS	12427	14289	11974	8324	10140	7860	10767	9897	9001
ITA TOT GT FISH DAYS	843741	1045203	921158	665155	772706	657556	892595	830323	832100
ITA TOT KW FISH DAYS	4136346	4386154	3817491	2584717	3254187	2769675	3729815	3448045	3307483

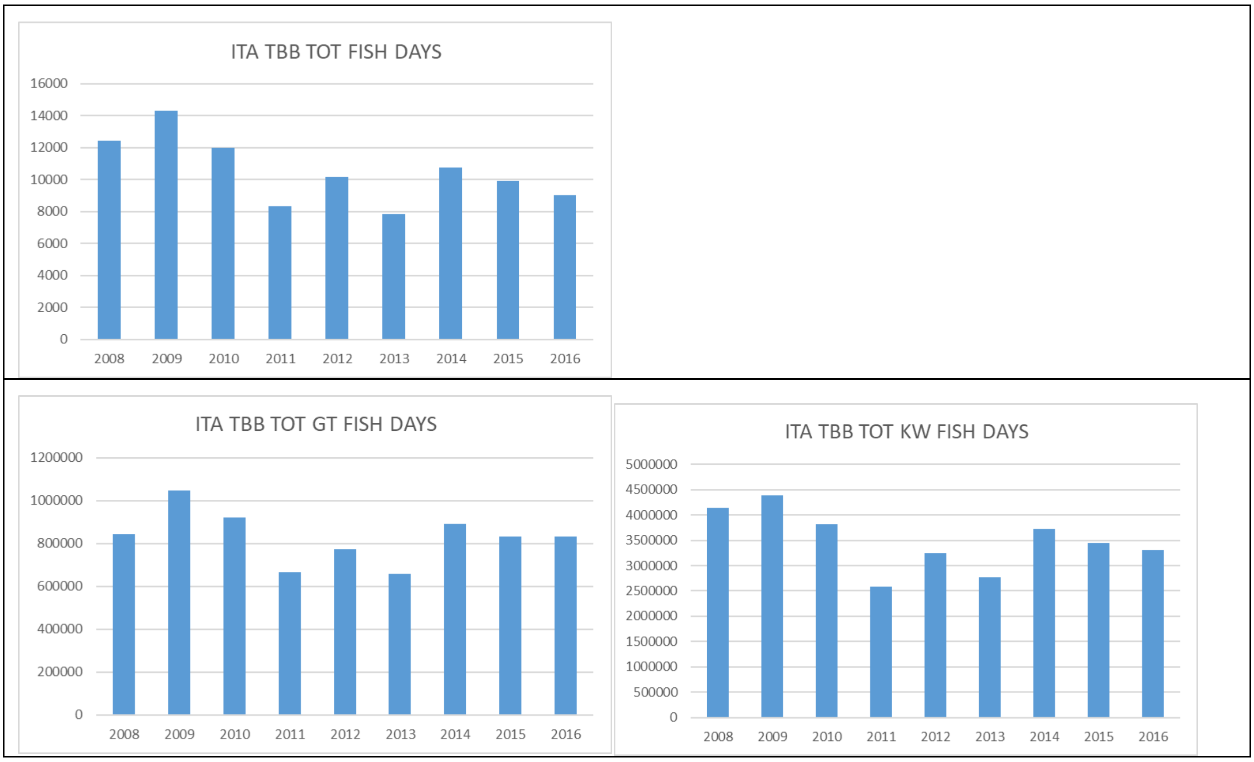


Figure 2.3.19. Trend of the TBB fishing effort in Italy

2.4 MSY REFERENCE POINTS FOR STOCKS IN THIS REPORT

For the stocks evaluated with age based assessments in this assessment meeting, the number of years of S-R data is very limited and it is not possible to carry out full evaluations of MSY, because the stock - recruit relationships cannot be established.

Following STECF decision in the absence of full MSY evaluations, and/or biomass reference points STECF considers that $F_{0.1}$ forms a good proxy for MSY. This for all stocks here with analytical assessments F0.1 has been evaluated based on the stock conditions over the last three years. MSY advice in terms of F and catch for 2019 are based on this approach.

For Nephrops and cuttlefish stocks, the models used are based on longer time series surplus production models, giving results in terms of F/Fmsy and B/Bmsy. In these cases there advice is given explicitly in the context of MSY criteria, so the reference points can be explicitly included in management.

In the case of Nephrops in GSA 17-18 which has a stable SPiCT assessment, biomass reference points have been proposed, based on the procedure used for sardine and anchovy in GSA 17-18 in the STECF Plenary in 2017. B_{lim} = 20% of B0 i.e. 40% of BMSY with simple surplus production model. In this case SSB was just below B_{lim} and the ICES MSY rule of F=FMSY*B/MSY$B_{trigger}$ was applied with MSY $B_{trigger}$ set to B_{pa}

2.4.1 MSY RANGES

The EWG has been requested to provide MSY ranges for the stocks considered by the EWG. The usual procedure used by ICES would be to establish S-R functions and to evaluate the ranges using this method, constraining the upper interval to be precautionary. As discussed above it has not been possible to establish such relationships for these stocks, either because the data series are too short.

To evaluate MSY ranges for stocks in this report the EWG uses the values of F associated with $F=F_{0.1}$ which are given in Table 2.2. These are the F_{MSY} values from the most updated assessments carried out on Mediterranean stocks assessment. Those values were then used in the formulas provided by STECF EWG 15-06 (STECF, 2015) to derive F_{MSY} range (F_{low} and F_{upp}). The empirical relationships used to estimate F_{MSY} range are the following:

$F_{low} = 0.00296635 + 0.66021447 \times F_{0.1}$

$F_{upp} = 0.007801555 + 1.349401721 \times F_{0.1}$

where $F_{0.1}$ is a proxy of F_{MSY}.

None of these methods add information on the precautionary nature of the F_{MSY} ranges; the values of F_{upp} and F_{low}. In the case of stock based on $F_{0.1}$ the F_{MSY} is considered to be precautionary, and because F_{low} is a lower exploitation rate this is will also be precautionary. As the WG is unable to parameterise stock recruit models and does not currently have B_{lim} reference values, it has not been possible to evaluate F_{upp} and notes that in contrast to demersal stocks for most small pelagic stocks evaluated (4 out of 5) F_{upp} is not found to be precautionary. Without explicit evaluation the values of F_{upp} should not be used for exploitation, and should be replaced with $F_{0.1}$.

2.4.2 VALUES OF FMSY FUPP AND FLOW

The values of F0.1, Fupp and Flow are calculated in the assessment sections Section 6 by species. The values are given in the short term forecast table in the stock assessment sections. These are reproduced in the table in Section 5 but with the Fupp value noted as not precautionary. This approach conforms to the one used by ICES (ICES 2014, ICES 2015)

ICES. 2014b. Report of the Joint ICES– MYFISH Workshop to consider the basis for F_{MSY} ranges for all stocks (WKMSYREF3), 17–21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64. 147 pp.

ICES 2015 Special Request Advice Greater North Sea and Baltic Sea Ecoregions ICES Advice 2015, Book 6 section 6.2.3.1 EU request to ICES to provide F_{MSY} ranges for selected North Sea and Baltic Sea stocks

2.5 SURVEY TIMING

The EWG notes a recommendation from Regional Co-ordination Group meeting for the Mediterranean and Black Sea 2017, (RCG MED&BS 2017 Recommendation 3) "*RCG recommends Mediterranean MS to carry out the MEDIT survey according to EUMAP provisions. In case of delays due to the MS administrative and bureaucratic procedures implementation, RCG recommends MS to take any actions to perform the MEDIT survey even with a delay with respect to EUMAP provisions.* ***RCG consider that from the scientific point of view it is better to perform the delayed surveys rather to not perform it at all, even if this involves a delay.***"

In this context the EWG has also noted Recommendation 93 from the GFCM WGSA. The WGSAD **recommended standardizing** not only commercial CPUE indices in particular, but also **survey indices** (and length frequency distributions), at least **when scientific surveys are carried out** in breach of standard protocols (e.g. in different times of the year).

The EWG discussed this issue and following the discussion the EWG noted that it is seriously concerned that the recommendation from RCGMBS gives misleading guidance. This situation for delayed surveys relates to the use of any survey not specifically MEDITS. The EWG considers the recommendation is problematic in two ways.

1. The EWG considers it is not correct to suggest that it is possible to model away the effect of delayed surveys, while this may be the case for a few situations; this is usually not the case for assessments (see below). Indeed it has been found that for information on recruitment, this is be particularly sensitive to correct protocols being followed for surveys and not possible to correct for survey timing within the model. It needs to be remembered that if a late or misplaced survey results in an unexpected value it is usually not possible to determine if the new value is indeed a true reflection of the situation or the result of the failure to follow the agreed program. So the effect of a delayed survey is that only 'expected'values become valid and the therefore value of the delayed survey is then questionable and only

surveys that can confirm the previous view of the stock are used. In such situations one questions the real value of the data from a delayed survey.

2. The statement that "it *is better to perform the delayed surveys rather to not perform it at all*"conveys completely the wrong incentive the MS, particularly if it is accompanied with no financial penalty. This approach directly enables non-compliance with the program. The EWG considers that this message is potentially damaging; and it needs to be clear that failure to comply with agreed timing protocols for surveys should necessarily result in recognition of a failure to carry out a mandated task, and this should have consequences. However, the EWG also noted that if survey is planned and started in accordance with agreed timing protocol, but finished with short delay due unforseen circumstance (i.e. bad weather, technical failures on research vessel or equipment, etc.), this should not be regarded as a failure.

The EWG recommends that STECF convey this message to those dealing with the organisation of the DCF programme.

The assertion that it is possible to model away changes in survey timing is only true for certain specific aspects, within some assessment models the timing of the survey can be set annually, allowing mortality and possibly growth to be correctly allocated before and after the survey. However, there are a number of aspects that cannot be modelled away under normal circumstances.

Inclusion of young of the year due to later surveys.

Change in catch rates due to size selection, particularly for youngest ages

Changes in stock location/availability due to movement/migration

Changes in survey q due to effects of day length or seasonal changes.

3 FOLLOW UP ITEMS

3.1 COMBINING OF SURVEYS INTO SINGLE INDICES

Surveys are used to provide tuning indices (at age) for stock assessment. For some areas and stocks multiple surveys of a similar type may be available covering parts of an area, these surveys may be for example the MEDITS surveys covering several GSAs that are being used to tune an assessment for a multi GSA stock such as deep water rose shrimp in GSAs 17-18-19 in this report, or may be MEDITS surveys that cover only part of a GSA where they are conducted by different counties, for example the MEDITS trawl surveys of GSA 17 and 18 by Italy and Croatia and used in the hake assessment. When more than one survey carried out on the same basis is to be used, the issue arises should this be combined, into a single survey or used in an assessment model as one index.

This issue was discussed at the EWG; the section here provides a summary of the issues and effects.

A survey that is suitable for tuning a stock assessment should be representative of that stock, i.e. covering the population being assessed, in the same way as the fishery on a stock is assumed to be fully estimated. In that sense a survey of part of an area may or may not cover the whole stock and thus may or may not represent the population (or at least some of the age classes in the population)

For surveys such as MEDITS carried out with the same standardised gear and protocol are assumed to perform in a similar manner in two areas. If there are differences in performance they are assumed to be small relative to the signals the survey is expected to capture. The individual surveys are assumed to be internally consistent and representative of the stocks of interest in their own survey area. Most of the issues associated with combining surveys relate to movement of the stock between survey areas. Figure 3.1.1 illustrates the type of movement considered.

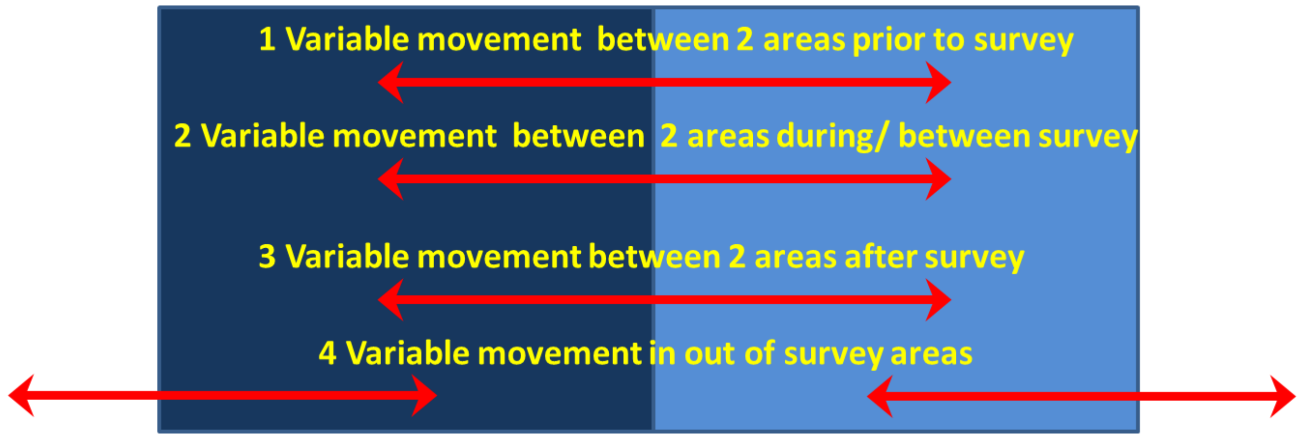


Figure 3.1.1. Types of movement considered as influencing the multiple and single combined indices.

Table 3.1.1 The effect of each type of motion described in Figure 3.1.1 on the fit of a survey index in a stock assessment, where the index is fitted with a q(at age), either as a combined index or as separate indices.

Source of error	**Combined Index**	**Separate Indices**
1 Prior movement, before survey starts	No influence on combined index value an increase in one area compensated by decrease in the other	Changes are seen in opposite directions in each index and give increased variance in model fit on both indices. – there is potential for different trends in each survey
2 Movement between/during survey(s) different in each year	Will cause changes in estimate of combined survey giving changes Q of combined survey (crudely double counting or missing fish), and may appear as year effects in a survey More generally migration introduces a multiplicative type error depending on the total duration for the 2 surveys and rate of movement between the two areas. (similar to within survey migration effects)	As with the combined index, both indexes change in same way (over or under estimating) and Qs will change. This results in increased variance in model fit, depending on magnitude of movement between surveys, and may appear as year effects in a survey Different trends in surveys possible, combined effect the in the model fit similar to combined survey. But depending on model type this can result in erroneous preference of one survey over the other, changing trend
3 After survey movement	No Influence	No Influence
4 migration into/out of total survey area	Changes Q, Increases variance in model fit. May result in potential for trend errors or year effects.	Changes Q. Increases variance in model fit. May result in potential for trend errors or year effects.
5 Sampling variance	More samples per index / one Q estimated, very slightly more statistical power from the same data	Fewer samples/survey 2 Qs estimated

Conclusions to choice of combine or not combine:-

- Consistent movement that is unchanging by year do not influence the outcome for either multi or combined indices (however, Q - at age – will be different to account for this effect)
- Overall a combined index is slightly more precise (has slightly lower variance) than separate indices and has only one Q(at age) to estimate in a model.

- A combined index is not influenced by movement occurring before survey starts, any increase in one area as the stock moves there prior to the survey is compensated for by the decrease in the other area. Whereas the use of separate indices will give increased variance in the fit, as the stock movement results in a 'year effects' in the multiple surveys in different directions.
- The effect of within/between survey movement results in very similar results when comparing combined / separate indices (provided the indices are weighted in the model by their proportion of the population). The effect of between survey area migration during the two surveys will cause Q to be more variable, but keeping the indices separate does not remove the problem.
- The multiple survey index approach can lead fitting issues if there is conflicting information in the two surveys. If separate indices are used, then relative index weighting in the model may be more difficult to select/control correctly in the model. A combined survey should already weight correctly across multiple indices, normally survey indices are weighted according to area covered. - i.e. according to each survey's total abundance.
- Conclusions :- There do not appear to be any advantages in fitting separate indices but there are some advantages in fitting a combined index, mostly better immunity to the effects of movement (differences in distribution) before the surveys start, and secondly ensuring the weighting of the multiple survey information in the model is dealt with consistently.

3.2 LENGTH TO AGE CONVERSION

Use of length to age slicing with age length curves.

While evaluating growth curves for length slicing in EWG 18-12 it became apparent that there was potential for misinterpretation of growth parameterisation when the stock has spawning centred on times of the year other than January and the assessment was run for the calendar year. This was particularly the case for relatively short lived species such as deep water rose shrimp and red mullet. The same issue was examined again in this EWG, and as the change implies differences in aging for at least three stocks the section is maintained here to allow quick access.

In these cases evaluation of growth curves indicated that some of these had been developed with time zero set at spawning time, with a small negative t_0 intercept to give the appropriate size as the fish move from larvae to juvenile stages.

When using the standard length slicing software (L2a) the main growth parameters are used directly so that ages up to age 1 at 12 months would be assigned to age 0. Those growing through the second 12 month period would be allocated to age 1 etc. If the stock assessment is run on a calendar year (Jan to Dec) this is approach is correct when the stock spawns at the beginning of the year, but not when the spawning time is later, say June-July. It would also be correct if the assessment year is matched to the spawning year. In the case that is typical for most stocks considered here with the assessment on a calendar year assessment (Jan to Dec), individuals must increase in age at 1 January, and if spawning is mid-year a nominal 6 months after then spawning must occur 6 months after time zero of the model growth model. In order to account for this t_0 can be modified by adding the fraction of the year before spawning. However, where the source of growth curve parameters is unknown or difficult to verify there is uncertainty regarding the correct approach. It is possible that if ages have been assigned to increment on 1st January, then the calculated (fitted) growth curve will be correct and not require further correction. Users need to match spawning times, assessment years and growth curves correctly.

Correction for 12 monthly derived growth curves from spawning time should be carried out for calendar year assessments with mid-year spawning. This is straightforward to do and has been done for critical stocks such as red mullet and deep water rose shrimp, where the source of growth curves is known. By doing this the numbers allocated to age zero are reduced and those allocated to older ages increased. Figure 3.1.1 illustrates the issue showing the most likely transition sizes at age 0 to 1 and age 1 to 2 under the different curve definitions. With the growth curve correction for calendar year assessment with spawning in June/July (t0 +0.5) individuals move from age 0 on 1st of January at around 18mm. If the assessment is set to July to June individuals transition at 27mm.

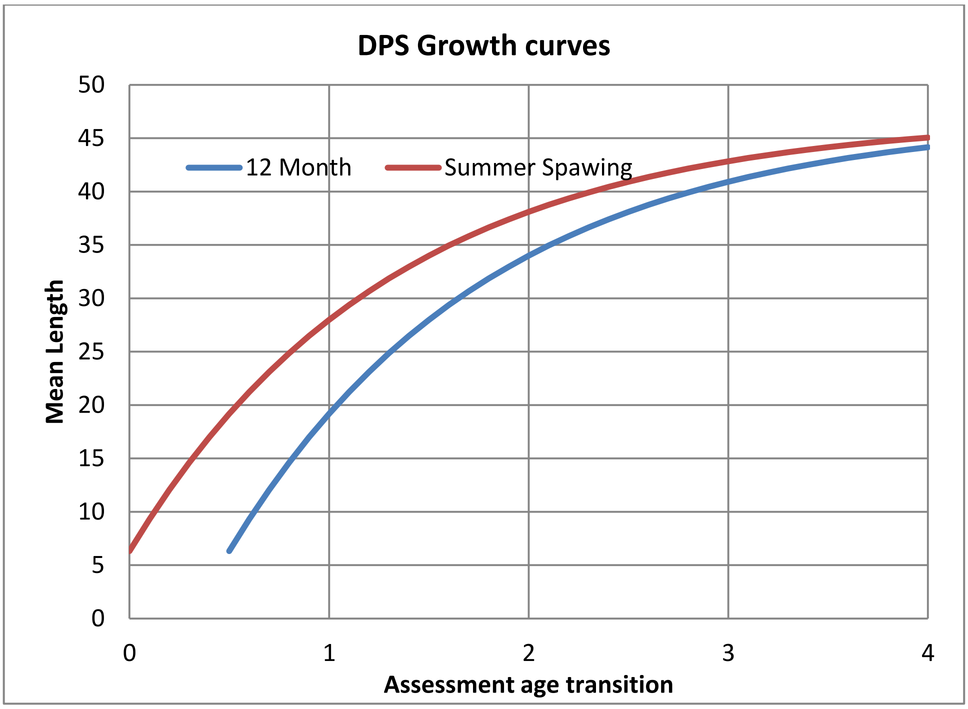


Figure 3.1.1 Illustration for assessment age transition (0-1, 1-2, 3-4) for different assessment year assumptions for DPS with and without the 0.5 year correction for summer spawning.

This problem is likely to be minor for stocks with longer lived species and few young individuals in the assessment (e.g. Nephrops), as any error in the zero time point becomes less important if the species live longer.

The problem however, does raise an issue that often it is unclear whether growth curves have been calculated based on true age (age from spawning) or calendar year age with birthdays set to 1 January, further checks need to be introduced.

Action: It is suggested that minor modifications be made to L2a scripts to drawn attention to these issues and provide appropriate corrections. The assessment year, spawning time, and survey time should all be checked to ensure a coherent approach.

In addition it may be possible to improve L2a for use with indices by explicitly using growth mode closely centred on the survey timing, this should be considered too.

4 MAIN STRUCTURE OF THE REPORT

The expert working group on Mediterranean stock and fisheries assessment part 1 STECF EWG 18-16 was held Rome (Italy), 15-21 October 2018.

Structure and basis of the report

The summary sheets by stock, provided in Section 5 contain catch advice. The basis of this advice depends on the type and quality of information available from the analyses and is as follows:

1) Full assessment and full MSY reference points or with surplus production model with F and biomass relative to F and Bmsy: Catch advice at MSY based on short term forecast**.-**
2) Full assessment without full evaluation MSY reference points due to short time historic series: Catch advice based on MSY proxy of F0.1 based on short term forecast.
3) Assessment providing SSB tend information historic F evaluation, not suitable for STF Catch / Effort advice under precautionary considerations (Patterson 1992) F=FMSY with Harvest Rate (HR) based estimated SSB in most recent year**.- not used in this report**
4) For sparse data with insufficient years for VPA type analysis, but with catch at length or age for most of the fishery: advice is based on pseudo cohort analysis at equilibrium, with estimate of current F relative to F0.1 **.- not used in this report**
5) Trend based indicator with exploitation and stock status know to be OK: Catch / Effort advice under precautionary considerations based on ICES

smoothed index of trend without precautionary buffer**.- not used in this report**

6) Trend based indictor: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend with precautionary buffer (20% reduction)**.- not used in this report**
7) Valid length analysis: statement of stock status, indication of direction of change required. **not used in this report**
8) No valid analysis: no advice. **not used in this report**

5 SUMMARY SHEETS BY STOCK

ToR 6. *To provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits, and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including MSY value, range of values and conservation reference points.*

5.1 SUMMARY SHEET FOR HAKE IN GSA 17-18

STECF advice on fishing opportunities

STECF EWG 18-16 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.18 and corresponding catches in 2019 should be no more than 2694 tons.

Stock development over time

Catches show a generally decreasing trend to 2016 (5761 tonnes), to slightly increase in the last year (6035 tonnes in 2017). SSB and recruitment show a more fluctuating trend over the years, depicting an increasing trend in the last years. Fbar(1-4) shows a quite stable trend over the years with a decreasing trend in the last years. The lowest value is observed in 2017 (Fbar = 0.60).

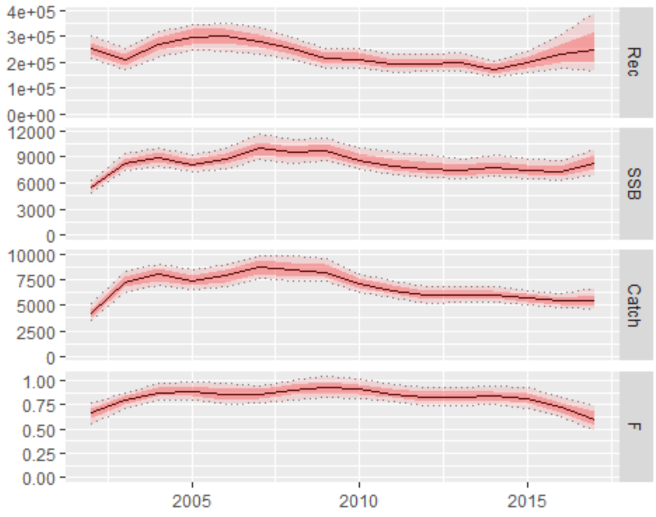


Figure 5.1.1 European hake in GSAs 17 and 18: Trends in catch, recruitment, fishing mortality resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above F_{MSY} (=0.18).

Table 5.1.1 European hake in GSAs 17 and 18: State of the stock and fishery relative to reference points.

Status	2015	2016	2017
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

Catch scenarios

Table 5.1.2 European hake in GSAs 17 and 18: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}4}$ (2018)	0.60	Equal to last year
SSB (2018)	10,770 t	From assessment of stock 1 January 2018
R_{age0} (2018 & 2019)	228,663 ('000)	Geometric mean of the last 16 years
Total catch (2018)	6,712 t	Assuming F = Fstatus quo

Table 5.1.3 European hake in GSAs 17 and 18: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2019)	F_{total}# (ages 0-2) (2019)	SSB (2020)	% SSB change***	% Catch change^^
STECF advice basis					
F_{MSY} / MAP	2694	0.18	20,480	90.2	-50.8
$F_{MSY\ lower}$	1874	0.12	21,669	101.1	-65.8
$F_{MSY\ upper}$**	3626	0.26	19,138	77.7	-33.8
Other scenarios					
Zero catch	0	0	24,412	126.7	-100.00
Status quo	7289	0.60	13,974	29.7	33.1

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

*** % change in SSB 2020 to 2018

^Total catch in 2019 relative to Catch in 2017.

^^ Total catch in 2019 relative to advice value 2018.

Basis of the advice

Table 5.1.4 European hake in GSAs 17 and 18: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Both catches and survey indices showed good internal consistency. The retrospective analysis run on the a4a model showed quite consistent results. All the diagnostics were considered acceptable.

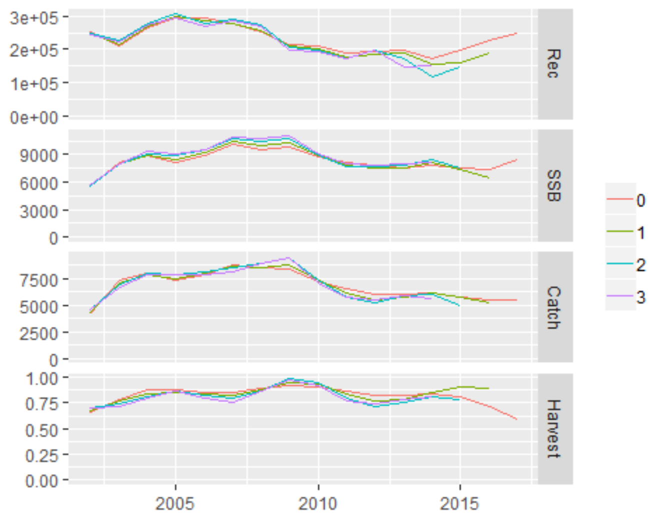


Figure 5.1.2 European hake in GSAs 17 and 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

This stock is taken in a mixed fishery with species such as red mullet, mantis shrimp and sole, therefore management of these stocks should be considered together.

Reference points

Table 5.1.5 European hake in GSAs 17 and 18: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.18	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		Not defined	
	MAP B_{lim}		Not defined	
	MAP F_{MSY}	0.18	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
	MAP target range F_{lower}	0.12	Based on regression calculation (see section 2)	STECF EWG 18-16
	MAP target range F_{upper}	0.26	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 18-16

Basis of the assessment

Table 5.1.6 European hake in GSAs 17 and 18: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards), plus commercial data provided by Albania and Montenegro from GFCM framework and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included; landings contain individual smaller than the minimum landing size
Indicators	
Other information	
Working group	STECF EWG 18-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.1.7 European hake in GSAs 17 and 18: STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landings	STECF discards
2019	F = F_{msy}		2694			

History of the catch and landings

Table 5.1.8 European hake in GSAs 17 and 18: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2017		Wanted catch				Discards
Catch (t)		Bottom trawl 64%	Longlines 9%	Trammel nets and set gillnet 1%	Rapido trawl 26%	t
		4451	604	81	1836	151
Effort		34825613	1501115	8173619	3328623	
		GT*Days at sea				

Table 5.1.9 European hake in GSAs 17 and 18: History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes.

Year	ITALY OTB GSA 18	ITALY LLS GSA 18	ITALY OTB GSA 17	SLOVENIA OTB GSA 17	CROATIA OTB GSA 17	CROATIA LLS GSA 17	MONTENEGRO OTB GSA 18	ALBANIA OTB GSA 18	Total landings	Total Effort
2002	2070	267	2308	2	521	41	39	200	5447	55699696
2003	2992	385	3062	5	384	30	75	384	7317	50666122
2004	3025	233	2894	1	566	45	93	473	7330	55262319
2005	3380	452	3833	2	726	57	52	267	8770	51525565
2006	4760	836	4064	3	768	61	55	280	10828	47922508
2007	3609	620	3508	6	818	65	54	275	8955	44081592
2008	3756	551	3101	1	532	33	63	275	8313	42558443
2009	3696	534	2603	2	734	37	56	336	7998	44848172
2010	3478	601	1903	0	572	40	49	280	6923	41585733
2011	3412	519	1469	0	653	37	40	286	6416	39244848
2012	2697	566	1783	0	796	34	42	899	6818	48705153
2013	2395	188	2195	1	1015	65	43	851	6752	45004371
2014	1630	279	1800	1	776	61	44	902	5494	44528913
2015	1700	427	2024	2	656	56	38	914	5817	43193299
2016	1779	492	1792	0	587	124	39	948	5761	43961435
2017	1713	514	1952	1	786	90	39	940	6035	47828970

Summary of the assessment

Table 5.1.10 European hake in GSAs 17 and 18: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (mean absolute deviance).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-4	High	Low
2002	253463	288967	217959	5479	6022	4936	5535	0.65	0.73	0.58
2003	210008	239001	181015	8207	8986	7428	7165	0.79	0.85	0.72
2004	266537	303535	229539	8946	9726	8166	7330	0.87	0.94	0.81
2005	294731	336097	253365	8177	8925	7429	8769	0.88	0.95	0.81
2006	296893	337934	255852	8843	9753	7933	10828	0.85	0.93	0.77
2007	279379	312656	246102	10076	11215	8937	8955	0.86	0.93	0.78
2008	251186	287390	214982	9600	10548	8652	8312	0.89	0.97	0.82
2009	212998	242918	183078	9839	10747	8931	7998	0.92	1.01	0.84
2010	212165	237793	186537	8742	9686	7798	6923	0.91	0.98	0.83
2011	191433	218993	163873	8132	9124	7140	6416	0.86	0.93	0.79
2012	192880	219120	166640	7840	8788	6892	6818	0.83	0.89	0.76
2013	198114	226330	169898	7522	8353	6691	6753	0.83	0.90	0.75
2014	171138	194161	148115	7873	8794	6952	5493	0.84	0.91	0.77
2015	199118	230150	168086	7552	8429	6675	5817	0.81	0.88	0.74
2016	229250	279513	178987	7431	8333	6529	5761	0.72	0.79	0.64
2017	248303	336775	159831	8391	9625	7157	6035	0.60	0.70	0.50

Sources and references

5.2 Summary sheet for red mullet in GSA 17-18

STECF advice on fishing opportunities

STECF EWG 18-16 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.41 in 2019,equivalent to catches of no more than 5083 tons in 2019 implemented either through catch restrictions or effort reduction for the relevant fleets.

Stock development over time

Catches of red mullet in GSAs 17-18 show a rather constant pattern, with a slight increase from 2012. Recruitment and SSB show an increasing trend from 2011 onwards. Fishing mortality showed a decreasing trend, from values around 1.0 at the beginning of the time series (2006) to 0.48 in 2017, despite the slight increase of catches in the most recent years.

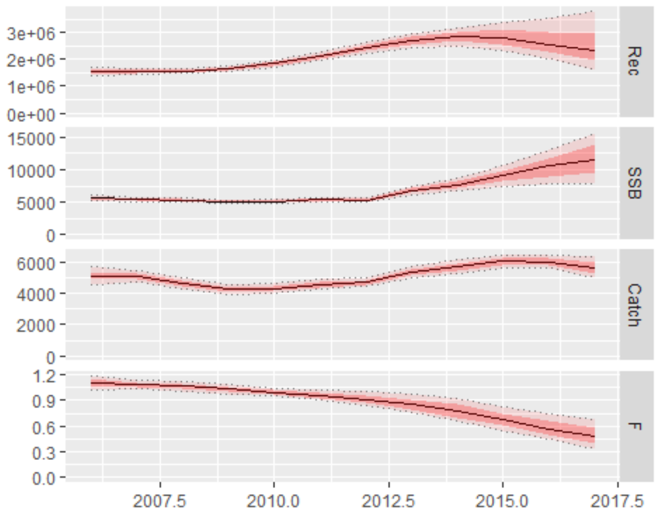


Figure 5.2.1 Red mullet in GSAs 17-18: Outputs of the a4a assessment

Stock and exploitation status

The current level of fishing mortality is above F_{MSY} (0.41).

Table 5.2.1 Red mullet in GSAs 17-18: State of the stock and fishery relative to reference points.

Status	2015	2016	2017
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

Catch scenarios

Table 5.2.2 Red mullet in GSAs 17-18 Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2018)	0.48	F current in the last year
SSB (2018)	11865 t	SSB from short term forecast
R_{age0} (2018 to 2020)	2535525	Geometric mean of R 2011 to 2017
Total catch (2018)	5773 t	Catch assuming status quo F in 2018

Table 5.2.3 Red mullet in GSAs 17-18 Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2019)	F_{total}# (ages 1-3) (2019)	SSB (2020)	% SSB change***	% Catch change^^
STECF advice basis					
F_{MSY} / MAP	5083	0.41	13334	12.2	-10.1
$F_{MSY\ lower}$	3606	0.27	15502	30.4	-36.2
$F_{MSY\ upper}$**	6519	0.56	11374	-4.3	15.3
Other scenarios					
Zero catch	0.0	0.0	21396	80.0	-100.0
Status quo	5746	0.48	12411	4.4	1.7

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

*** % change in SSB 2020 to 2018

^Total catch in 2019 relative to Catch in 2017.

^^ Total catch in 2019 relative to advice value 2018.

Basis of the advice

Table 5.2.4 Red mullet in GSAs 17-18 The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Both catches and survey indices showed good internal consistency. The retrospective analysis run on the a4a model showed consistent results. All the diagnostics were considered acceptable.

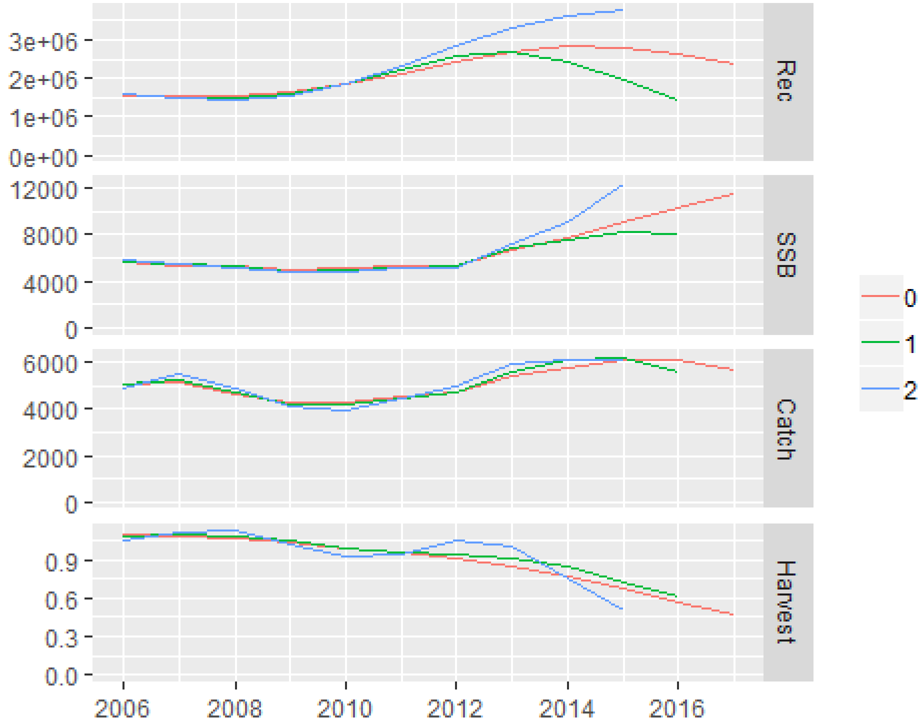


Figure 5.2.2 Red mullet in GSAs 17-18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Data Quality

In 2006, LFDs data for commercial fisheries are not available in GSA18. In 2017, the MEDITS survey in GSAs 17 and 18 was performed in a later period compared to the usual period of the MEDITS survey and could not be used. . The survey data for 2017 were used in the assessment; however, due to inconstancy of survey timing the age-0 was removed from the survey data for the whole time series.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.2.5 Red mullet in GSAs 17-18 Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.41	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		Not defined	

	MAP B_{lim}		Not defined	
	MAP F_{MSY}	0.41	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
	MAP target range F_{lower}	0.27	Based on regression calculation (see section 2)	STECF EWG 18-16
	MAP target range F_{upper}	0.56	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 18-16

Basis of the assessment

Table 5.2.6 Red mullet in GSAs 17-18 Basis of the assessment and advice.

Assessment type	Age based
Input data	Landings at length to landings at age (age slicing)
Discards, BMS landings*, and bycatch	Discards included
Indicators	MEDITS in GSAs 17-18
Other information	
Working group	STECF EWG 18-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.2.7 Red mullet in GSAs 17-18 STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landings	STECF discards
2019	F = F0.1		5083			

History of the catch and landings

Table 5.2.8 Red mullet in GSAs 17-18 Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

(2017)		Wanted catch							Discards
Catch (t)		OTB_17ITA 64.5%	OTB_17HRV 17.1%	OTB_18ITA 9.8%	NET_18ITA 1.1%	OTB_18ALB 6.8%	OTB_18MTN 0.6%	NET_18MTN 0.1%	t
	5798	tonnes							1089
Effort	1523054	52.2%	21.4%	24.8%	1.6%	NA	NA	NA	
		Nominal effort (GT*fishing days)							

Table 5.2.9 Red mullet in GSAs 17-18 History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes.

Year	OTB_17ITA	OTB_17HRV	OTB_18ALB	OTB_18MTN	NET_18MTN	OTB_18ITA	NET_18ITA	TOTAL
2006	3101					1803	130	5034
2007	3299		171			1680	123	5273
2008	3158	767	149	38	3.7	914	47	5077
2009	2433	818	154	36	3.6	955	77	4477
2010	1979	763	90	35	3.4	601	45	3517
2011	2694	1086	110	32	3.2	494	38	4457
2012	1849	1248	375	35	3.5	2089	8	5607
2013	2271	1086	373	32	3.1	1203	47	5015
2014	2844	1158	317	41	4	1250	23	5637
2015	3129	1127	388	36	3.6	1572	15	6271
2016	2541	951	396	36	3.6	1398	50	5375
2017	3744	990	392	36	3.6	566	67	5798

Summary of the assessment

Table 5.2.10 Red mullet in GSAs 17-18 Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors intervals (Median Absolute Deviance).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2006	1526151	1645755	1406547	5602	5873	5331	5074	1.10	1.16	1.04
2007	1526428	1599214	1453642	5370	5618	5122	5112	1.08	1.12	1.04
2008	1558639	1632139	1485139	5280	5519	5041	4619	1.06	1.10	1.01
2009	1654707	1741668	1567746	5035	5239	4831	4238	1.03	1.08	0.98
2010	1836043	1929540	1742546	5126	5364	4888	4307	0.99	1.03	0.96
2011	2101404	2219478	1983330	5375	5637	5113	4571	0.95	1.00	0.91
2012	2411939	2582625	2241253	5319	5628	5010	4708	0.91	0.97	0.85
2013	2685772	2903411	2468133	6764	7280	6248	5382	0.85	0.93	0.78
2014	2828251	3121971	2534531	7645	8477	6813	5715	0.77	0.88	0.67
2015	2793590	3241466	2345714	9015	10344	7686	6102	0.67	0.78	0.56
2016	2619415	3276198	1962632	10306	12442	8170	6063	0.57	0.69	0.45
2017	2391365	3219339	1563391	11433	14643	8223	5652	0.48	0.60	0.35

Sources and references

5.3 Summary sheet for Norway lobster in GSA 17-18

STECF advice on fishing opportunities

STECF EWG 18-16 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.35 and corresponding catches in 2019 should be no more than 745 tons.

Stock development over time

The assessment shows a continuous reduction in B/Bmsy since 60s, with values consistently below 1 since the mid-90s with the last 3 years being among the lowest point of the series. Exploitation in terms of F/F_{msy} indicates an increasing trend since early '90s with values over 1 since mid 2000, leveling off above F_{msy} in the last few years.

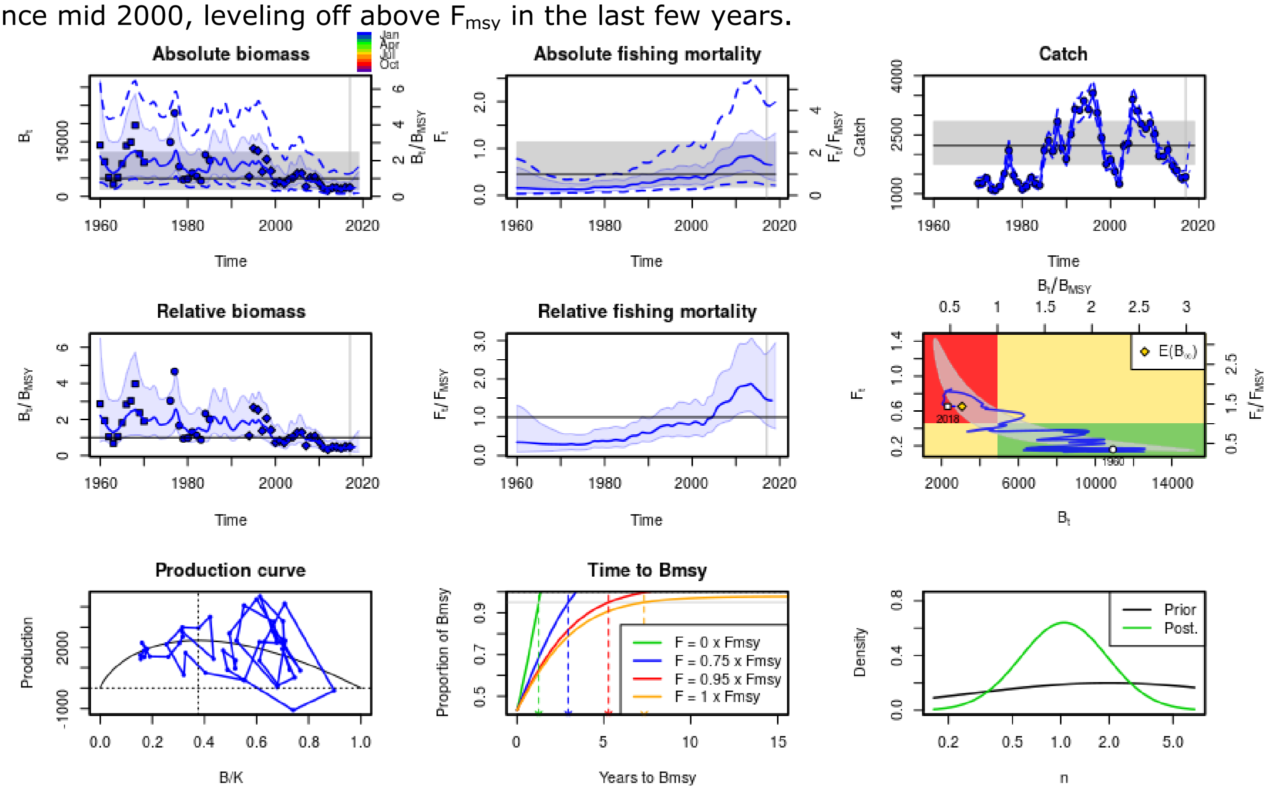


Figure 5.3.1 Norway lobster in GSA 17 and 18. SPICT model main outputs.

Stock and exploitation status

The status of the stock in 2017 using mean value by year, refered to the stochastic reference points (B_{MSYs} F_{MSYs}) is F_{2017}/F_{MSYs} = 1.46 and B_{2017}/B_{MSYs} = 0.43. When referred to the deterministic reference points, the stock status in 2017 is F_{2017}/F_{MSYd}= 1.46 and B_{2017}/B_{MSYd} = 0.41.

Table 5.3.1 Norway lobster in GSA 17 and 18. State of the stock and fishery relative to reference points.

Status	2015	2016	2017
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

B / Bmsy	B < Bmsy	B < Bmsy	B < Bmsy
B / Bpa	B < Bpa	B < Bpa	B < Bpa

Catch scenarios

Predictions of stock growth in the short term forecast of the SPiCT model give unrealistic increases in biomass, as they apply average stock growth at status quo F, which is considered unlikely. Recently the stock has maintained almost constant biomass at Fs similar to that for 2017 for the last few years, showing no signs of stock growth. Short term forecasts are based on no stock growth through 2018 assuming Fstatus quo (F2017). The EWG advices using a reduced exploitation rate for 2019 (F=0.77Fmsy) due to low biomass (B<Bpa). STECF does not advise fishing at Fmsy until biomass is estimated to be above Bpa.

Table 5.3.2 Norway lobster in GSA 17 and 18. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ all}$ (2018)	0.663	Harvest rate from production model (SPICT)
Catch (2018)	1430.5 t	
Biomass 2018 & 2019	2128	Assuming no growth in the population with status quo F in 2018

Table 5.2.3 European hake in GSAs 9, 10 and 11: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2019)	F (all) (2019)	SSB (2020)	% SSB change***	% Catch change^^
STECF advice basis					
Reduced Fmsy (B<Bpa)	745.4	0.35##			
F_{MSY} / MAP	958	0.45			
$F_{MSY\ lower}$	631	0.30			
$F_{MSY\ upper}$**	1308	0.61			
Other scenarios					
Zero catch					
Status quo	1431	0.663			

The advised exploitaion rate for nephrops GSA 17-18 is based on a reduced harvest rate due to the low biomass (B<Bpa): Fmsy= 0.45 is reduced to F=0.35

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

*** % change in SSB 2020 to 2018

^Total catch in 2019 relative to Catch in 2017.

^^ Total catch in 2019 relative to advice value 2018.

Basis of the advice

Table 5.3.4 Norway lobster in GSA 17 and 18. The basis of the advice.

Advice basis	F_{MSY}, B_{msy} reduced F due to B<Bpa
Management plan	

Quality of the assessment

All the diagnostics were considered acceptable. The retrospective analysis run on the a4a model showed consistent results.

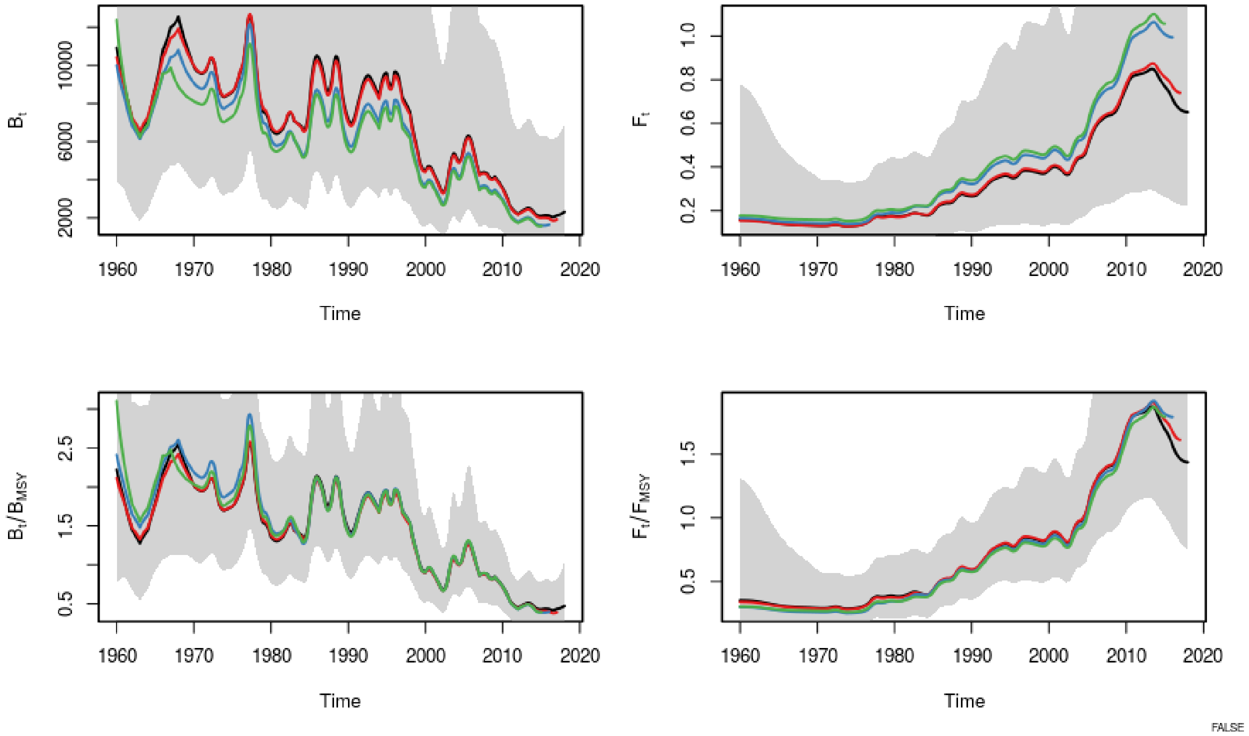


Figure 5.2.3 Norway lobster in GSA 17 and 18. Historical assessment results. (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.3.5 Norway lobster in GSA 17 and 18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	*MSY $B_{trigger}$	2751.8	MSY Btrigger = Bpa = Blim*1.4	STECF EWG 18-16
	F_{MSY}	0.45	Fmsy from SPiCT model	STECF EWG 18-16
Precautionary approach	B_{lim}	1965.6	Blim = 40% Bmsy	
	B_{pa}	2751.8	Bpa = Blim*1.4	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	*MAP MSY $B_{trigger}$	2751.8	MSY Btrigger = Bpa = Blim*1.4	STECF EWG 18-16
	MAP B_{lim}	1965.6	Blim = 40% Bmsy	STECF EWG 18-16
	MAP F_{MSY}	0.45	Fmsy reduced of B<Bpa	STECF EWG 18-16
	MAP target range F_{lower}	0.30	Based on regression calculation (see section 2)	STECF EWG 18-16
	MAP target range F_{upper}	0.61	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 18-16

* Target F is reduced below Fmsy if B<MSY $B_{trigger}$ The reduction is = Fmsy*B/MSY $B_{trigger}$

Basis of the assessment

Table 5.3.6 Norway lobster in GSA 17 and 18. Basis of the assessment and advice.

Assessment type	Production model (SPICT)
Input data	DCF commercial data (landings), historical landings (FAO-GFCM and ISTAT), scientific survey (MEDITS) data and historical surveys
Discards, BMS landings*, and bycatch	
Indicators	
Other information	
Working group	STECF EWG 18-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.3.7 Norway lobster in GSA 17 and 18. STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landings	STECF discards
2019	F = F_{msy}		745.4			

History of the catch and landings

Table 5.3.8 Norway lobster in GSA 17 and 18. Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2017		Wanted catch		Discards
Catch (t)		Otter trawl 97.3%	FPO 2.7%	t
		1391.71	38.65	3.11
Effort				
		GT*Days at sea		

Table 5.3.9 Norway lobster in GSA 17 and 18. History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes.

Year	ITALY-CROATIA-ALBANIA-MONTENEGRO GSA17-18	Total landings	Total BMS landings	STECF total landings	Total Effort
1970	1270				
1971	1283				
1972	1397				
1973	1113				
1974	1098				
1975	1197				
1976	1520				
1977	2104				
1978	1469				
1979	1288				
1980	1116				
1981	1185				
1982	1407				
1983	1270				
1984	1219				
1985	2109				
1986	2350				
1987	2087				
1988	2836				

1989	2159				
1990	1890				
1991	2507				
1992	3151				
1993	3122				
1994	3366				
1995	3148				
1996	3558				
1997	3058				
1998	2426				
1999	1753				
2000	1864				
2001	1559				
2002	1252				
2003	2219				
2004	2279				
2005	3394				
2006	3107				
2007	2775				
2008	2654				
2009	2800				
2010	2523				
2011	1956				
2012	1955				
2013	2117				
2014	1716				
2015	1596				
2016	1398				
2017	1431				

*** No landings in Slovenia**

Summary of the assessment

Table 5.3.10 Norway lobster in GSA 17 and 11: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Biomass tonnes	High	Low	Catch tonnes	F ages all	High	Low
1970	9705.53			1270	0.13		
1971	9741.71			1283	0.13		
1972	10127.07			1397	0.14		
1973	8663.75			1113	0.13		
1974	8465.42			1098	0.13		
1975	8986.16			1197	0.13		
1976	10495.21			1520	0.15		
1977	11987.49			2104	0.17		
1978	8632.41			1469	0.17		
1979	7280.13			1288	0.18		
1980	6484.06			1116	0.17		
1981	6690.32			1185	0.18		
1982	7368.16			1407	0.19		
1983	6944.48			1270	0.18		
1984	6940.24			1219	0.18		
1985	9674.53			2109	0.21		
1986	9992.61			2350	0.23		
1987	8881.68			2087	0.24		
1988	10147.07			2836	0.27		
1989	8083.42			2159	0.27		
1990	7101.16			1890	0.27		
1991	8333.28			2507	0.30		
1992	9364.26			3151	0.33		
1993	8849.36			3122	0.35		

1994	9202.76	3366	0.36
1995	9143.70	3148	0.35
1996	9297.62	3558	0.38
1997	7985.70	3058	0.38
1998	6499.07	2426	0.37
1999	4817.44	1753	0.37
2000	4615.82	1864	0.40
2001	3988.03	1559	0.39
2002	3547.08	1252	0.37
2003	5067.02	2219	0.42
2004	5149.08	2279	0.45
2005	6145.09	3394	0.54
2006	5146.39	3107	0.60
2007	4362.05	2775	0.63
2008	4134.36	2654	0.65
2009	3893.07	2800	0.72
2010	3145.22	2523	0.80
2011	2387.06	1956	0.82
2012	2335.81	1955	0.83
2013	2465.46	2117	0.84
2014	2168.28	1716	0.80
2015	2129.34	1596	0.75
2016	2069.73	1398	0.68
2017	2195.18	1431	0.66

Sources and references

5.4 Summary sheet for Deep-water rose shrimp in GSA 17-18-19

STECF advice on fishing opportunities

STECF EWG 18-16 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.65 and corresponding to catches of no more than 2635 tons in 2019.

Stock development over time

The Deep water rose shrimp in GSAs 17-18-19 shows increasing catch from 2016 to 2017, stable in the previous years. SSB increasing in the last two years. F decreasing in the last 3 years, now at its lowest level since 2010.

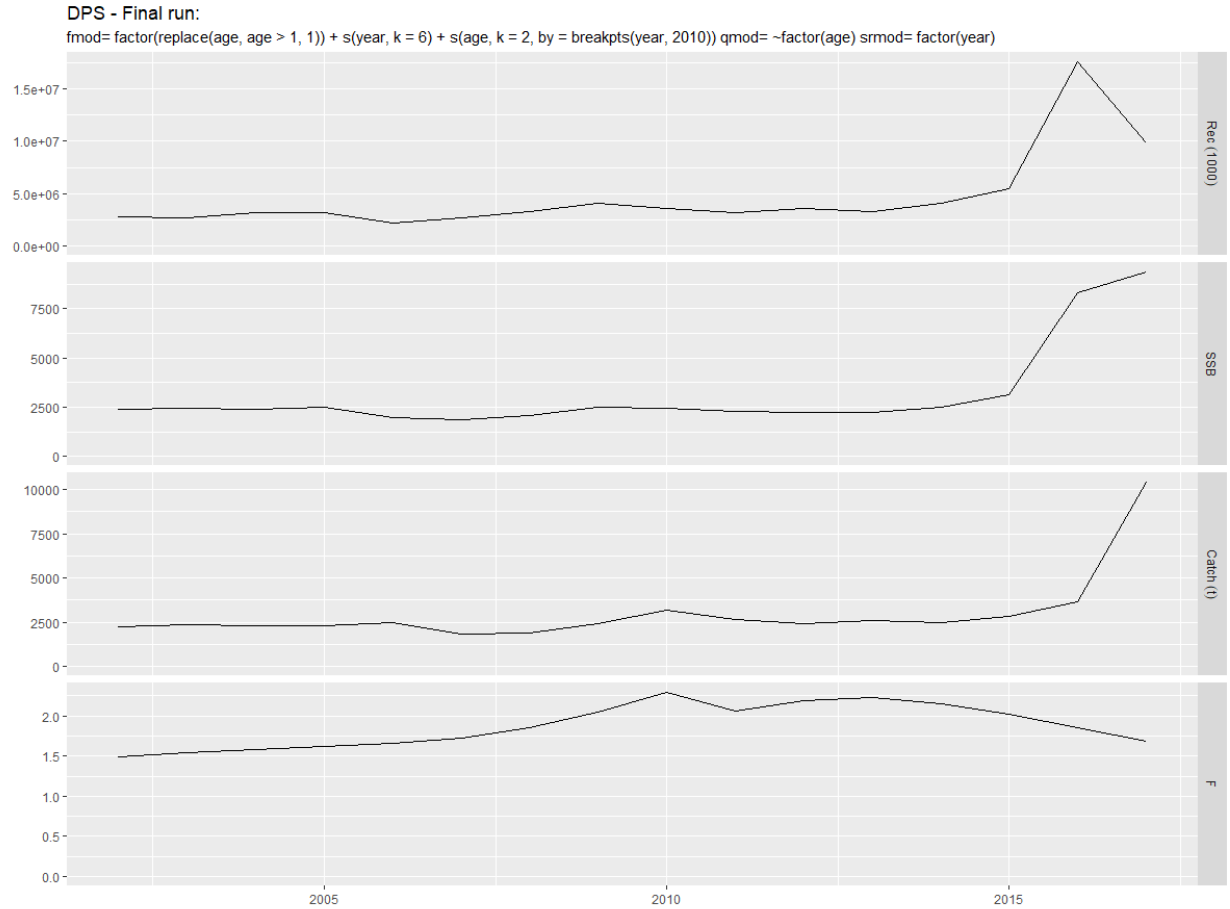


Figure 5.4.1 Deep-water rose shrimp stocks in GSAs 17-19: Stock summary Recruitment SSB, catch and fishing mortality ages 1-2.

Stock and exploitation status

The current level of fishing mortality is above F_{MSY} (=0.65).

Table 5.4.1 **Deep-water rose shrimp stocks in GSAs 17-19**: State of the stock and fishery relative to reference points.

Status	2015	2016	2017
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

Catch scenarios

Table 5.4.2 Deep-water rose shrimp stocks in GSAs 17-19: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 0\text{-}2}$ (2018)	1.69	F status quo = F2017
SSB (2018)	6124	Terminal assessment year
R_{age} (2018)	5186919	Geometric mean recruitment 2010 to 2017
R_{age} (2019)	5186919	Geometric mean recruitment 2010 to 2017
Total catch (2018)	8466	Estimated catch based on Fstatus quo

Table 5.4.3 Deep-water rose shrimp stocks in GSAs 17-19: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2019)	F_{bar} (ages 1-2) (2019)	SSB (2020)	% SSB change***	% TAC change^	% Advice change^^
STECF advice basis						
F_{MSY} / MAP	2635.0	0.65	6124.2	1.4	-75	
$F_{MSY\ lower}$	1903.4	0.43	7054.8	16.8	-82	
$F_{MSY\ upper}$**	3294.5	0.89	5365.4	-11.2	-68	
Other scenarios						
F=0	0.0	0.00	9910.9	64.1	-100	
$F=F_{2017}$	4847.9	1.69	3866.3	-36.0	-53	
$F=F_{2017}$ * 0.8	4303.0	1.35	4348.3	-28.0	-59	
$F=F_{2017}$ * 0.6	3609.0	1.01	5029.9	-16.7	-65	
$F=F_{2017}$ * 0.4	2713.9	0.68	6029.4	-0.2	-74	
$F=F_{2017}$ * 0.2	1545.1	0.34	7544.7	24.9	-85	

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

***SSB 2020 relative to SSB 2019.

^Total catch in 2019 relative to Catch in 2017.

^^ Total catch in 2019 relative to advice value 2018.

Basis of the advice

Table 5.4.4 Deep-water rose shrimp stocks in GSAs 17-19: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The time series of available data is short assessment is poor but considered sufficient for the advice. The retrospective does not perform well but does not change the status of the stock over the last three years (F>Fmsy)

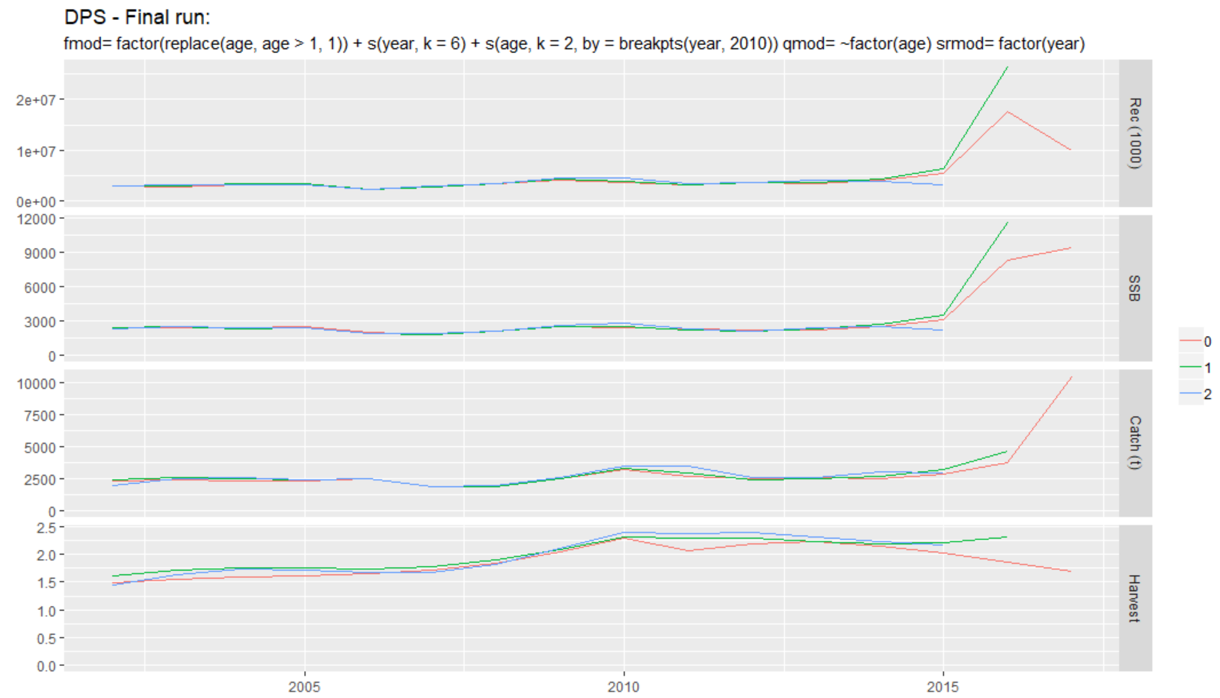


Figure 5.4.2 Deep-water rose shrimp stocks in GSAs 17-19: Historical assessment results (Retrospective graph) with one and two years removed.

Issues relevant for the advice

Nephrops is often caught in mixed trawl fisheries and could be managed together with other species.

Reference points

Table 5.4.5 Deep-water rose shrimp stocks in GSAs 17-19: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.65	$F_{0.1}$ as proxy for F_{MSY}	EWG 18-16
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		Not defined	
	MAP B_{lim}		Not defined	

	MAP F_{MSY}	0.65	$F_{0.1}$ as proxy for F_{MSY}	
	MAP target range F_{lower}	0.43	Based on regression calculation (see section 2)	
	MAP target range F_{upper}	0.89	Based on regression calculation but not tested and presumed not precautionary	

Basis of the assessment

Table 5.4.6 Deep-water rose shrimp stocks in GSAs 17-19: Basis of the assessment and advice.

Assessment type	Age based assessment
Input data	MEDITS survey raised to mean catch total weight at length and catch data based on sampling giving total catch at length
Discards, BMS landings, and bycatch	Discards are sampled giving a value at length. Discards were included in the total catch
Indicators	MEDITS survey
Other information	
Working group	EWG 18-16

History of the advice, catch, and management

Table 5.4.7 Deep-water rose shrimp stocks in GSAs 17-19: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	Agreed TAC	STECF landings	STECF discards
2017	F=Fmsy		2635			

History of the catch and landings

Table 5.4.8 Deep-water rose shrimp stocks in GSAs 17-19: Catch distribution by fleet in YEAR as estimated by and reported to STECF.

Catch (current year-1)	Wanted catch				Discards
5483 tonnes	Otter trawl 100%	%	%	Other %	negligible
	Tonnes				

Table 5.4.9 Deep-water rose shrimp stocks in GSAs 17-19: History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes

Year	HRV 17	ITA 17	ITA 18	ALB 18	MNE 18	ITA 19	STECF total landings
2002	142	61	920	222	35	1476	2855.7
2003	142	61	1276	222	35	1292	3028.2
2004	142	61	1882	222	35	2340	4682.1
2005	142	61	1203	222	35	2486	4148.9
2006	142	62	1489	222	35	2490	4439.8
2007	142	76	879	309	39	1216	2660.9
2008	71	59	782	309	39	1570	2830.1
2009	139	48	970	275	36	1534	3001.7
2010	175	71	906	7	32	1432	2622.4
2011	152	95	875	209	27	1186	2544.3
2012	170	58	530	1170	22	976	2925.7
2013	317	86	746	1210	31	668	3057.6
2014	365	230	646	1430	28	844	3542.8
2015	536	316	665	1290	31	1244	4081.9
2016	657	678	1017	1460	32	1294	5137.6
2017	844	593	1151	1473	35	1386	5482.5

Summary of the assessment

Table 5.4.10 Deep-water rose shrimp stocks in GSAs 17-19: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

year	Recruitment age 0 thousands	SSB tonnes	Catch tonnes	F age 1-2
2002	2785160	2411	2268	1.49
2003	2748991	2445	2350	1.54
2004	3184531	2381	2276	1.59
2005	3219191	2501	2304	1.62
2006	2194468	1987	2490	1.65
2007	2724979	1846	1841	1.72
2008	3269371	2096	1868	1.85
2009	4126159	2494	2436	2.04
2010	3575085	2440	3214	2.29
2011	3200568	2277	2676	2.06
2012	3633111	2236	2442	2.19
2013	3278316	2250	2605	2.23
2014	4073328	2500	2499	2.15
2015	5439999	3131	2852	2.02
2016	17553416	8335	3683	1.85
2017	9883771	9359	10408	1.69

Sources and references

5.5 SUMMARY SHEET FOR COMMON CUTTLEFISH IN GSA 17-18

STECF advice on fishing opportunities

STECF EWG 18-16 advises, that when MSY considerations are applied, fishing mortality can be increased to Fmsy. As common cuttlefish is a short living species, living mostly up to 1-1.5 year, annual catches in 2019 will depend mostly on growth within 1st year of life, and therefore no specific catch options can be provided fopr 2019. Catch at Fmsy with current biomass (Bmsy) is estimated at 7600 tonnes.

Stock development over time

Biomass has increased in recent years and is estimated to be at Bmsy. F has decreased over recent years and is estimated to be well below Fmsy. The data does not allow for evaluation of recruitment over time, so current recruitment cannot be compared with historic recruitment.

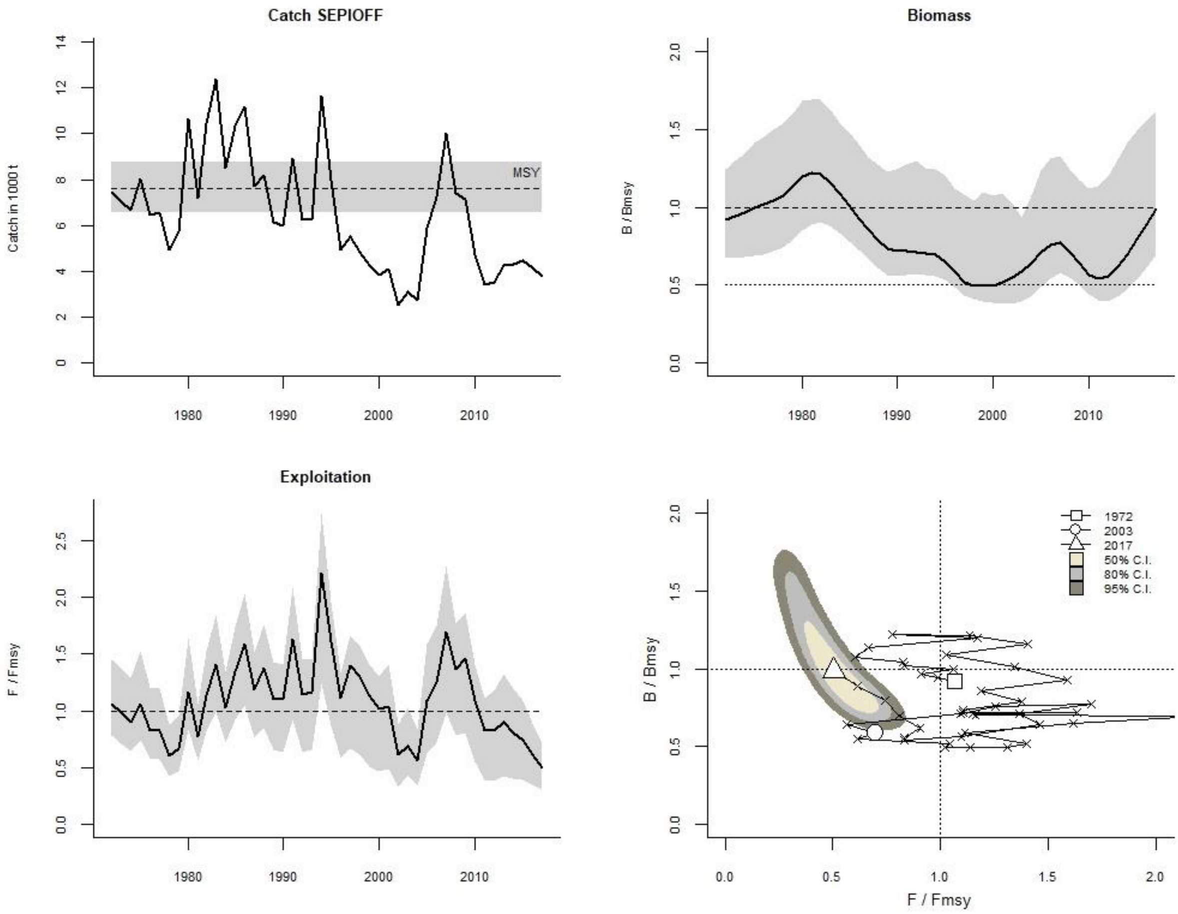


Figure 5.5.1 Common cuttlefish in GSA 17-18. Trends in catch, relative biomass and exploitation as given by CMSY model. 95% confidence limits (grey) are also indicated.

Stock and exploitation status

The assessment estimates B to be very close to Bmsy and B/Bmsy in last year is 0.986. The current level of fishing mortality is below the reference point F_{MSY} (F/ F_{MSY} =0.503).

Table 5.5.1 Common cuttlefish in GSA 17-18. State of the stock and fishery relative to reference points.

Status	2015	2016	2017
F / Fmsy	F < Fmsy	F < Fmsy	F < Fmsy
B/Bmsy	B<Bmsy	B<Bmsy	B=Bmsy

Catch scenarios

Considering the fact that common cuttlefish is a short living species, living mostly up to 1-1.5 year, annual catches depend mostly on growth condition of this species within 1st year of life, and therefore short term catch forecast cannot be carried out, and no specific catch options can be provided. Average MSY catch at current biomass (Bmsy) is estimated at 7600 tonnes.

Basis of the advice

Table 5.5.4 Common cuttlefish in GSA 17-18 The basis of the advice.

Advice basis	Fmsy
Management plan	

Quality of the assessment

The current assessment results align well with the observed trends in the surveys (biomass and density indices). Growth and natural mortality of common cuttlefish are assumed constant over the time-series. The MEDITS surveys are assumed to have the same catchability for all the years, but taking into consideration different survey periods in last few years.

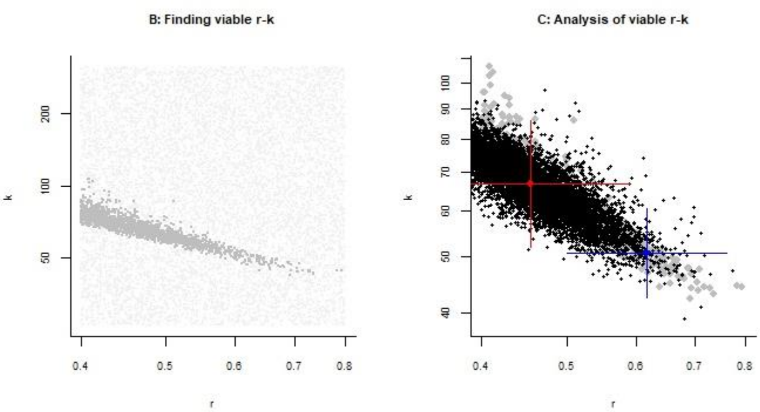


Figure 5.5.2. Common cuttlefish in GSA 17-18. Monte-Carlo analysis of catch and priors for r and B/k.

Issues relevant for the advice

Common cuttlefish is caught as part of a mixed fisheries.

Reference points

Table 5.5.5 Common cuttlefish in GSA 17-18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.228	F_{MSY} estimated from CMSY model	STECF EWG 18-16
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		Not defined	
	MAP B_{lim}		Not defined	
	MAP F_{MSY}	0.228	F_{MSY} estimated from CMSY model	
	MAP target range F_{lower}	0.176	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 18-16
	MAP target range F_{upper}	0.294	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 18-16

Basis of the assessment

Table 5.5.6 Common cuttlefish in GSA 17-18. Basis of the assessment and advice.

Assessment type	Production models
Input data	DCF commercial data (landing and discard) and Economic transversal data, FAO FishStat, Istat and EUROSTAT database, EU-RECFISH Project, data provided by DG-MARE, national fishery statistics and scientific surveys (MEDITS) data
Discards, BMS landings*, and bycatch	Discard <0.01% (assumption made: landing=catch)
Indicators	
Other information	
Working group	STECF EWG 18-16

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.5.7 Common cuttlefish in GSA 17-18. STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted catch corresp. to advice	Official landings in GSA9
2019	$F=F_{MSY}$	7600	

History of the catch and landings

Table 5.5.8 Common cuttlefish in GSA 17-18. Landing distribution by fishing gears and discard in period 2006-2017 as reported to DCF.

	Landings by gears (DCF landing 2006-2017)								Discards (2006-2017)
Catch	OTB 54.2%	FPO 19.9%	TBB 13.7%	GNS 8.1%	GTR 3.2%	FYK 0.9%	LLS <0.1%	-1 <0.1%	(All gears) <0.1%
(t)	25,377 t	9,335 t	6.396 t	3.787 t	1.486 t	429	7 t	4 t	25 t

Table 5.5.9 Common cuttlefish in GSA 17-18. History of commercial landings of common cuttlefish in the Adriatic Sea (GSA 17 and GSA 18); both the official reported values are presented by country and STECF estimated landings. All weights are in tonnes.

Year	CROATIA GSA 17	SLOVENIA GSA 17	ITALY GSA 17	ITALY GSA 18	MONTENEGRO GSA 18	ALBANIA GSA 18	Ex Yugoslavia (SLO, HRV & MTN)	**Total (t)**
1972			6151	1109			174	**7433**
1973			5818	1086			160	**7063**
1974			5411	1063			192	**6666**
1975			6360	1432			218	**8010**
1976			4845	1357			244	**6446**
1977			5093	1273			194	**6560**
1978			3589	1163			170	**4922**
1979			4441	1148			140	**5729**
1980			9158	1289			199	**10646**
1981			6161	869			159	**7189**
1982			9203	1103			146	**10451**
1983			10379	1808			176	**12363**

1984			7244	1118			153	**8515**
1985			8955	1230			148	**10333**
1986			7987	3069			144	**11199**
1987			6336	1215			177	**7728**
1988			6534	1462			219	**8216**
1989			4724	1224			200	**6147**
1990			4902	835			276	**6013**
1991			6917	1854			158	**8929**
1992	154	12	4621	1442	2			**6231**
1993	187	21	4693	1322	6			**6229**
1994	109	4	10368	1185	5			**11671**
1995	109	10	6193	1620	9	39		**7979**
1996	94	6	4000	798	10	33		**4941**
1997	139	5	4563	755	9	33		**5504**
1998	198	18	3710	868	10	51		**4856**
1999	134	18	3431	593	10	51		**4237**
2000	127	11	2756	884	10	50		**3838**
2001	78	72	2707	1220	10	22		**4109**
2002	41	22	1447	981	10	52		**2553**
2003	65	25	2270	710	10	43		**3122**
2004	36	29	2005	597	10	70		**2747**
2005	74	33	4074	1630	8	75		**5893**
2006	65	24	5008	2040	15	86		**7239**
2007	84	41	8603	1207	18	47		**10000**
2008	73	15	6276	960	15	62		**7401**
2009	68	14	5683	1243	7	126		**7141**
2010	86	7	3375	1140	9	98		**4715**
2011	105	8	2324	866	11	90		**3403**
2012	169	10	2575	663	12	80		**3510**
2013	189	4	2956	1018	11	85		**4263**
2014	207	6	3195	811	13	75		**4306**
2015	192	4	3293	879	14	82		**4464**
2016	112	5	2975	970	14	83		**4160**
2017	106	3	1951	1617	14	83		**3774**

Summary of the assessment

Table 5.5.10 Common cuttlefish in GSA 17-18 Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals)

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F/Fmsy ages 0-2	High	Low
2004				21.4	35.8	14.3	2747	0.563	0.843	0.337
2005				23.7	41.2	16.3	5893	1.09	1.594	0.629
2006				25.4	43.8	18.2	7239	1.253	1.746	0.726
2007				25.9	44.4	19.3	10000	1.7	2.278	0.989
2008				23.9	41.6	18.4	7401	1.362	1.768	0.782
2009				21.5	39.1	16.8	7141	1.46	1.867	0.802
2010				18.9	37.5	14.7	4715	1.095	1.411	0.552
2011				18	37.8	13.4	3403	0.83	1.118	0.396
2012				18.5	39.9	13.1	3510	0.832	1.178	0.386
2013				20.7	43.7	14.2	4263	0.906	1.32	0.429
2014				23.4	47.1	15.8	4306	0.809	1.195	0.402
2015				26.5	49.7	17.9	4464	0.74	1.093	0.395
2016				29.7	51.9	20.5	4160	0.616	0.894	0.353
2017				32.9	54.1	23.2	3774	0.503	0.714	0.307

Sources and references

5.6 SUMMARY SHEETS FOR SOLE IN GSA 17

Two optios are included in the report, both give similar catch options and similar stock status.

5.6.1 SUMMARY SHEET FOR SOLE IN GSA 17(A4A)

STECF advice on fishing opportunities

STECF EWG 18-16 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.15 and corresponding catches in 2019 should be no more than 662 tons.

Stock development over time

The peak of recruitment in 2013 provided a peak of SSB and catch in 2014, followed by a decrease which seems to be bringing the stock back to values previous to 2014. Last year catch is, though, still higher than catches previous than 2014. Consistently, fishing mortality has been increasing between 2012 and 2015, but despite the decrease in Catch, SSB and recruitment, it has been decreasing as well from 2015.

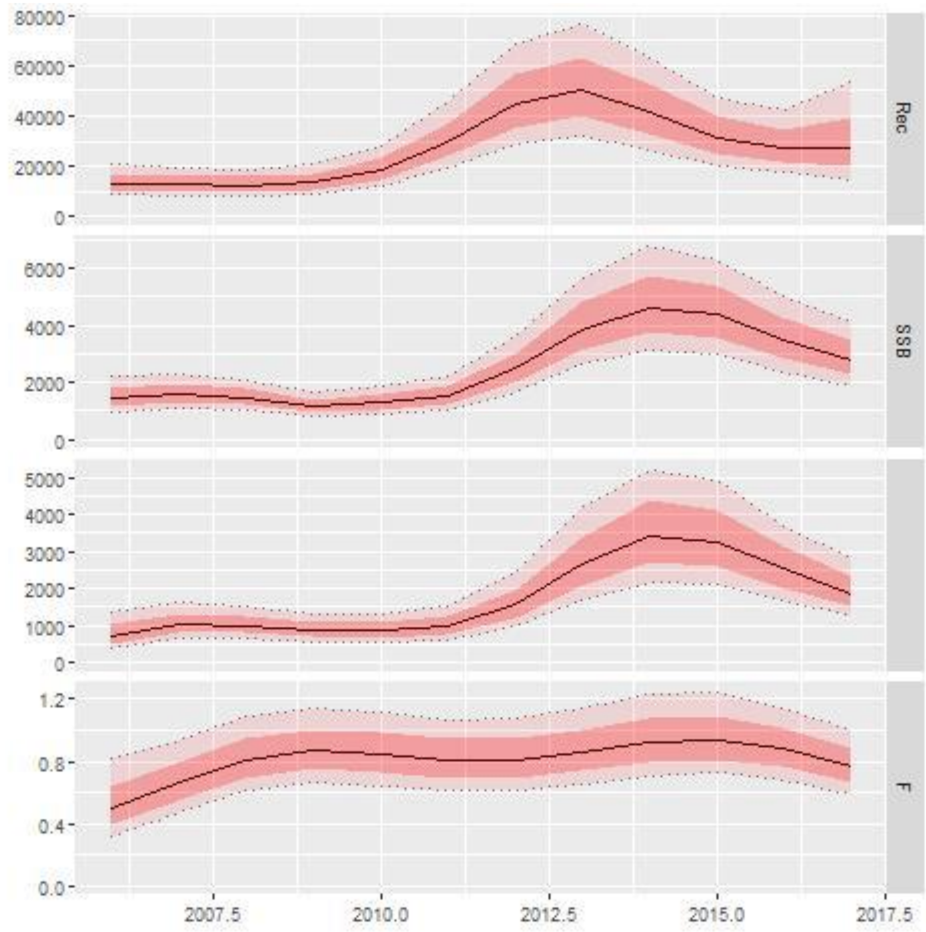


Figure 5.6.1.1 Sole in GSA 17. Output of the a4a assessment. SSB and catch are in tonnes, recruitment in number of individuals.

Stock and exploitation status

The current level of fishing mortality is above F_{MSY} (=0.15).

Table 5.6.1.1 Sole in GSA 17: State of the stock and fishery relative to reference points.

Status	2015	2016	2017
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

Catch scenarios

Table 5.6.1.2 Sole in GSA 17 Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2018)	0.74	F in 2017
SSB (2018)	3006	SSB from short term forecast
R_{age0} (2018)	34978	The geometric mean of the last seven years (2011-2017)
Total catch (2018)	1942	Catch assuming status quo F in 2018

Table 5.6.1.3 Sole in GSA 17 Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2019)	F_{total}# (ages 1-3) (2019)	SSB (2020)	% SSB change***	% Catch change^^
STECF advice basis					
F_{MSY} / MAP	662	0.15	5523	83.73	-64.35
$F_{MSY\ lower}$	466	0.10	5754	91.41	-74.91
$F_{MSY\ upper}$**	888	0.21	5256	74.84	-52.14
Other scenarios					
Zero catch	0	0	3425	109.68	-100
Status quo	2221	0.74	3694	22.88	19.65

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

*** % change in SSB 2020 to 2018

^Total catch in 2019 relative to Catch in 2017.

^^ Total catch in 2019 relative to advice value 2018.

Basis of the advice

Table 5.6.1.4 Sole GSA 17 The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The retrospective analysis run on the a4a model showed consistent results and the diagnostics were considered acceptable. Retrospective performance was considered acceptable as the states of the stock (F>Fmsy) was unchanged.

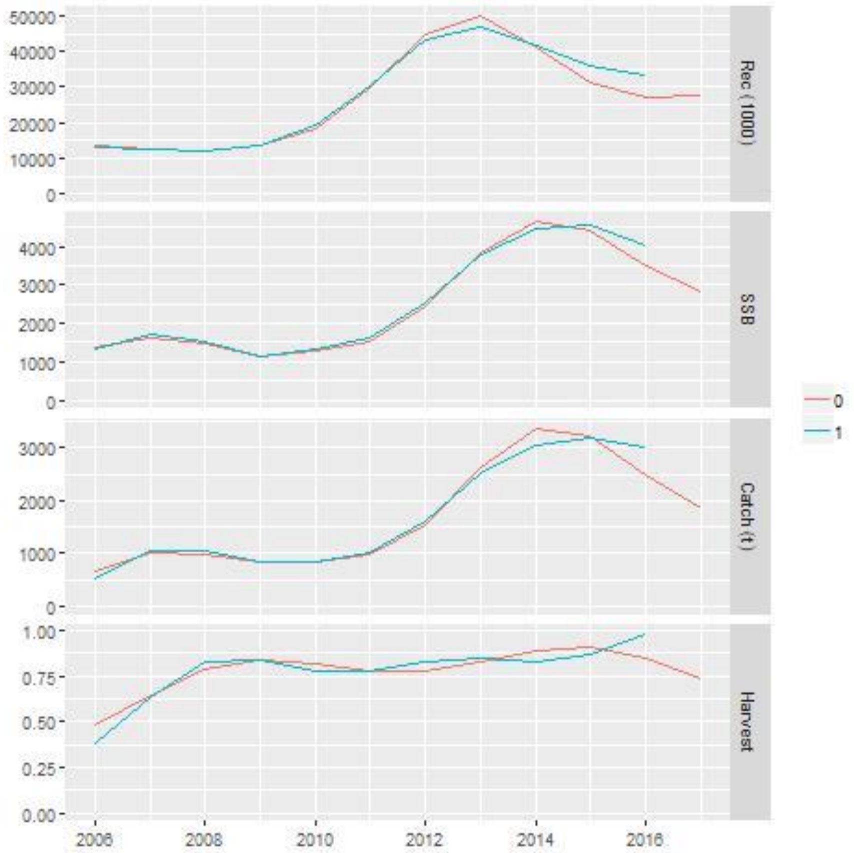


Figure 5.6.1.2 Sole in GSA 17 Historical assessment results (final-year recruitment estimates included).

Total landings and length frequency distributions were reconstructed for Italian gillnets in 2009 and 2010, for Italian Otter trawls from 2007 to 2010 and length frequency distributions for Croatian Trammel nets from 2006 to 2012.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.6.1.5 Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.15	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		Not defined	
	MAP B_{lim}		Not defined	
	MAP F_{MSY}	0.15	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
	MAP target range F_{lower}	0.10	Based on regression calculation (see section 2)	STECF EWG 18-16
	MAP target range F_{upper}	0.21	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 18-16

Basis of the assessment

Table 5.6.1.6 Sole in GSA 17 Basis of the assessment and advice.

Assessment type	Statistical catch at age with a4a
Input data	DCF commercial data (landings) and scientific survey data (Solemon)
Discards, BMS landings*, and bycatch	Discards NOT included due to negligible values (often 0)
Indicators	-
Other information	-
Working group	STECF EWG 18-16

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.6.1.7 Sole in GSA 17 STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landings	STECF discards
2019	F = F_{MSY}	662	662			

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landing s	STECF discard s

History of the catch and landings

Table 5.6.1.8 Sole in GSA 17 Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2017		Wanted catch				Discards
Catch (t)		Bottom trawl 71.3%	Gillnets 21.5%	Trammel nets 7.1%	Other 0%	Negligible
		2257 tonnes				
Effort		19837245	1899953	2226125	0	
		GT*kwh Nominal effort				

Table 5.6.1.9 Sole in GSA 17 History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes.

Year	Italy (GSA 17)	Croatia (GSA 17)	Slovenia (GSA 17)	Total landings	Total BMS landings	STECF total landings	Total Effort
2006	1822		5	1828		1828	29212794.06
2007	1158		8	1166		1166	27302646.57
2008	986		7	993		993	26747208.71
2009	850		10	860		860	26678289.42
2010	665		8	673		673	25436635.8
2011	1261		13	1274		1274	23971895.29
2012	1687		8	1695		1695	24926391.34
2013	994	185	14	1193		1193	20942751.26
2014	1904	106	14	2024		2024	24308946.92
2015	1857	187	13	2057		2057	22700196.03
2016	1911	116	11	2038		2038	23293746.34
2017	2098	150	13	2261		2261	23963323.36

Summary of the assessment

Table 5.6.1.10 Sole in GSA 17 Assessment summary. Weights are in tonnes. 'High' and 'Low' are the credible intervals (Median Absolute Deviance).

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 2-6	High	Low
2006	13276	17497	9055	1460	626.83	-369.17	736	0.5	0.685	0.315
2007	12606	16580	8632	1609	584.71	-339.29	1035	0.66	0.841	0.479
2008	12190	16224	8156	1471	605.64	-222.36	1006	0.81	0.992	0.628
2009	13470	17920	9020	1147	576.11	-89.89	858	0.87	1.056	0.684
2010	18558	24774	12342	1265	606.57	-123.43	850	0.85	1.024	0.676
2011	29719	39217	20221	1529	736.25	-181.75	967	0.81	0.983	0.637
2012	44808	46256	43360	2460	1021.54	-448.46	1555	0.81	0.987	0.633
2013	49792	51425	48159	3834	409.93	183.93	2651	0.86	1.046	0.674
2014	40842	42142	39542	4592	403.17	137.17	3391	0.92	1.116	0.724
2015	31108	32109	30107	4343	363.45	119.45	3226	0.94	1.137	0.743
2016	27461	36730	18192	3421	1203.84	-720.16	2481	0.88	1.052	0.708
2017	27776	29104	26448	2816	1101.94	-588.06	1855	0.76	0.93	0.59

Sources and references

5.6.2 SUMMARY SHEET FOR SOLE IN GSA 17 (SS3)

STECF advice on fishing opportunities

STECF EWG 18-16 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.24 and corresponding catches in 2019 should be no more than 659 tons.

Stock development over time

The peak of recruitment in 2013 provided an increasing of SSB and catch in 2014 and 2015, followed by a stabilization of the stock. Fishing mortality strongly decreased from 2009 to 2013, then slightly increased until 2017.

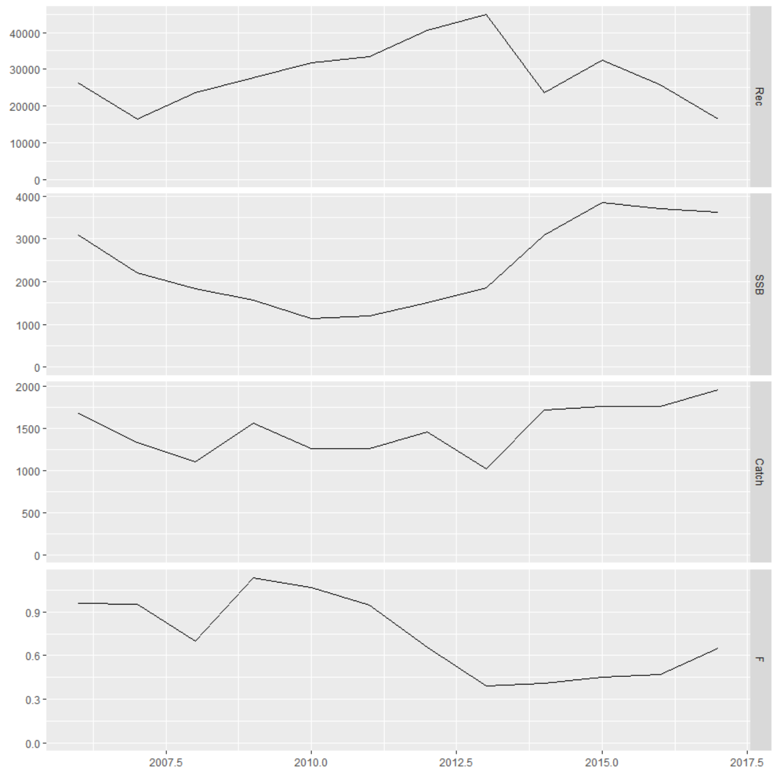


Figure 5.6.2.1 Sole in GSA 17. Output of the a4a assessment. SSB and catch are in tonnes, recruitment in number of individuals.

Stock and exploitation status

The current level of fishing mortality is above F_{MSY}.

Table 5.6.2.1 Sole in GSA 17: State of the stock and fishery relative to reference points.

Status	2015	2016	2017

F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

Catch scenarios

Table 5.6.2.2 Sole in GSA 17 Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2018)	0.65	F in 2017
SSB (2018)	2926	SSB from short term forecast
R_{age0} (2018)	29593	The geometric mean of the last seven years (2011-2017)
Total catch (2018)	1519	Catch assuming status quo F in 2018

Table 5.6.2.3 Sole in GSA 17 Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2019)	F_{total}# (ages 1-3) (2019)	SSB (2020)	% SSB change***	% Catch change^^
STECF advice basis	659	0.24	3023	34	-66
F_{MSY} / MAP	460	0.16	3249	23	-55
$F_{MSY\ lower}$	873	0.33	2782	44	-76
$F_{MSY\ upper}$**					
Other scenarios	0	0	3778	67	-100
Zero catch	1497	0.65	2095	-7	-23
Status quo	659	0.24	3023	34	-66

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

*** % change in SSB 2020 to 2018

^Total catch in 2019 relative to Catch in 2017.

^^ Total catch in 2019 relative to advice value 2018.

Basis of the advice

Table 5.6.2.4 Sole GSA 17 The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The retrospective analysis run on the SS3 model showed consistent results and the diagnostics were considered acceptable. Retrospective performance was considered acceptable as the states of the stock (F>Fmsy) was unchanged.

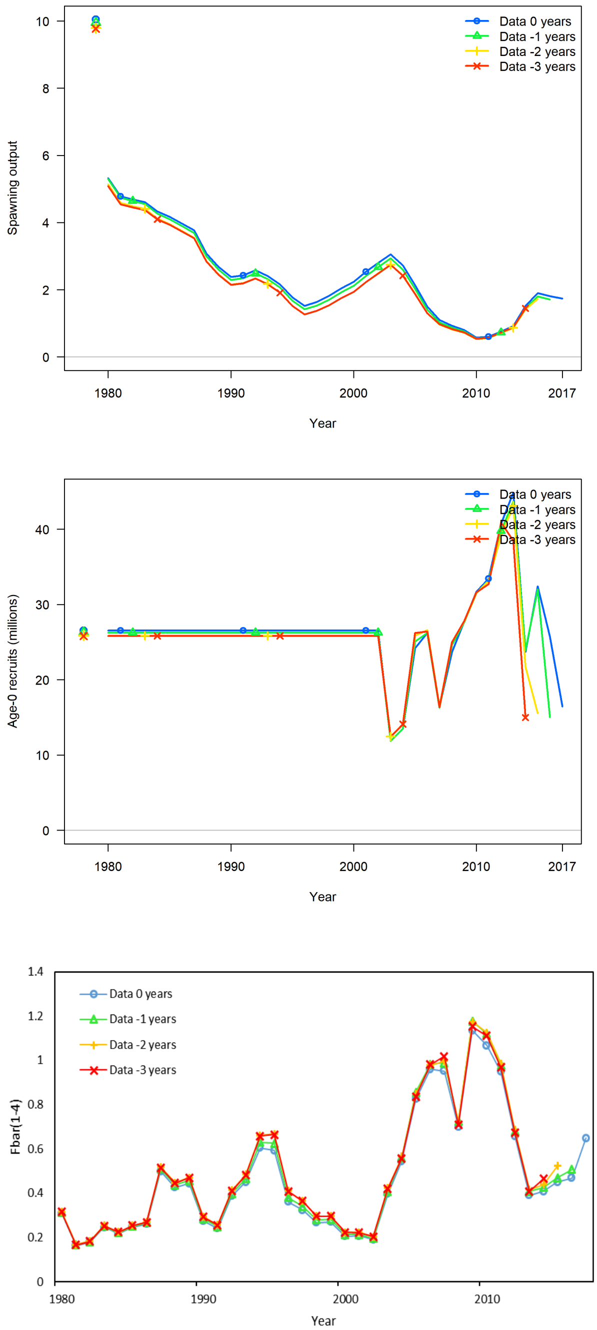


Figure 5.6.2.2 Sole in GSA 17 Historical assessment results (final-year recruitment estimates included).

Total landings and length frequency distributions were reconstructed for Italian gillnets in 2009 and 2010, for Italian Otter trawls from 2007 to 2010 and length frequency distributions for Croatian Trammel nets from 2006 to 2012.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.6.2.5 Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.24	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		Not defined	
	MAP B_{lim}		Not defined	
	MAP F_{MSY}	0.24	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 18-16
	MAP target range F_{lower}	0.16	Based on regression calculation (see section 2)	STECF EWG 18-16
	MAP target range F_{upper}	0.33	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 18-16

Basis of the assessment

Table 5.6.2.6 Sole in GSA 17 Basis of the assessment and advice.

Assessment type	Statistical catch at age with SS3
Input data	DCF commercial data (landings) and scientific survey data (Solemon)
Discards, BMS landings*, and bycatch	Discards NOT included due to negligible values (often 0)
Indicators	-
Other information	-
Working group	STECF EWG 18-16

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.6.2.7 Sole in GSA 17 STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landings	STECF discards
2019	F = F_{MSY}	659	659			

History of the catch and landings

Table 5.6.2.8 Sole in GSA 17 Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2017		Wanted catch				Discards
Catch (t)		Bottom trawl 71.3%	Gillnets 21.5%	Trammel nets 7.1%	Other 0%	Negligible
		2257 tonnes				
Effort		19837245	1899953	2226125	0	
		GT*kwh Nominal effort				

Table 5.6.2.9 Sole in GSA 17 History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes.

Year	Italy (GSA 17)	Croatia (GSA 17)	Slovenia (GSA 17)	Total landings	Total BMS landings	STECF total landings	Total Effort
2006	1823	194	5	2022		2022	29212794.06
2007	1379	201	8	1588		1588	27302646.57
2008	1185	133	7	1325		1325	26747208.71
2009	1643	301	10	1954		1954	26678289.42
2010	1421	185	8	1614		1614	25436635.8
2011	1331	245	13	1589		1589	23971895.29
2012	1687	164	8	1859		1859	24926391.34
2013	1000	239	14	1253		1253	20942751.26
2014	1912	122	14	2048		2048	24308946.92
2015	1857	175	13	2045		2045	22700196.03
2016	1976	106	11	2093		2093	23293746.34
2017	2097	147	13	2257		2257	23963323.36

Summary of the assessment

Table 5.6.2.10 Sole in GSA 17 Assessment summary. Weights are in tonnes. 'High' and 'Low' are the credible intervals (Median Absolute Deviance).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-4	High	Low
2006	26228			3005.6			2022	0.96		
2007	16425			2199.2			1588	0.95		
2008	23644			1856.4			1325	0.70		
2009	27721			1602.1			1954	1.13		
2010	31691			1142.2			1614	1.07		
2011	33428			1196.8			1589	0.95		
2012	40726			1507.7			1859	0.66		
2013	44877			1842.7			1253	0.39		
2014	23710			3039.4			2048	0.41		
2015	32419			3797.7			2045	0.45		
2016	25738			3626.4			2093	0.47		
2017	16444			3467.2			2257	0.65		

Sources and references

5.7 SUMMARY SHEET FOR SPOTTAIL MANTIS SHRIMP IN GSA 17-18

STECF advice on fishing opportunities

STECF EWG 18-12 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.41 and corresponding catches in 2019 should be no more than 2742 tons.

Stock development over time

Catches and SSB of Spottail mantis shrimp show an increasing trend in the last three years. The assessment shows an increasing trend the last five years with a high uncertainty the last two years. Fbar (1-3) shows a fluctuating pattern within the last three years.

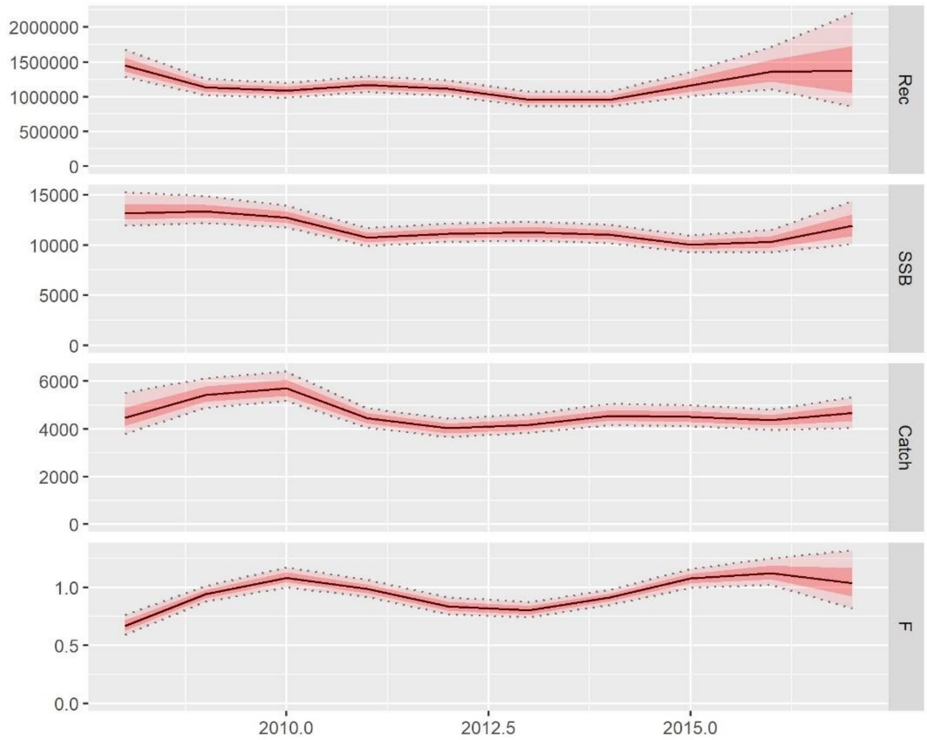


Figure 5.7.1 Spottail mantis shrimp in GSA 17 and 18: Trends in catch, spawning stock biomass, recruitment and fishing mortality resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above F_{MSY} (=0.41).

Table 5.7.1 Spottail mantis shrimp in GSA 17 and 18 : State of the stock and fishery relative to reference points.

Status	2015	2016	2017
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

Catch scenarios

Table 5.7.2 Spottail mantis shrimp in GSA 17 and 18 Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2018)	1.04	Mean F of the last 3 years
SSB (2018)	12832	From assessment of stock 1 January 2018
R_{age0} (2018, 2019)	1295293	Geometric mean of the last 3 years
Total catch (2018)	5305 (t)	Assuming F = Fstatus quo

Table 5.7.3 Spottail mantis shrimp in GSA 17 and 18 Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2019)	F_{total}# (ages 1-3) (2019)	SSB (2020)	% SSB change***	% Catch change^^
STECF advice basis					
F_{MSY} / MAP	2742	0.41	15538	21.08	-41.32
$F_{MSY\ lower}$	2941	0.28	16438	28.10	-58.45
$F_{MSY\ upper**}$	3524	0.57	14668	14.31	-24.58
Other scenarios					
Zero catch	0	0	18654	45.37	-100.00
Status quo	5406	1.04	12622	-1.64	15.70
0.2 * Status quo	1501	0.21	16937	31.98	-67.88
0.4 * Status quo	2744	0.42	15536	21.07	-41.27
0.6 * Status quo	3783	0.62	14382	12.08	-19.03
0.8 * Status quo	4660	0.83	13424	4.61	-0.28
1.2 * Status quo	6048	1.25	11942	-6.93	29.43

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

*** % change in SSB 2020 to 2018

^Total catch in 2019 relative to Catch in 2017.

^^ Total catch in 2019 relative to advice value 2018.

Basis of the advice

Table 5.7.4 Spottail mantis shrimp in GSA 17 and 18 The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Catches and survey indices showed a moderate internal consistency. The restrospective analysis run on the a4a model showed consistent results only for the catch. Fishing mortality showed a difference of around 10% between the original model and the ones with removed years, but does not change the perception of F>Fmsy in any recent years. Recruitment showed the larger instability as information on recruitment is poor. Over all the assessment is considered acceptable for advice.

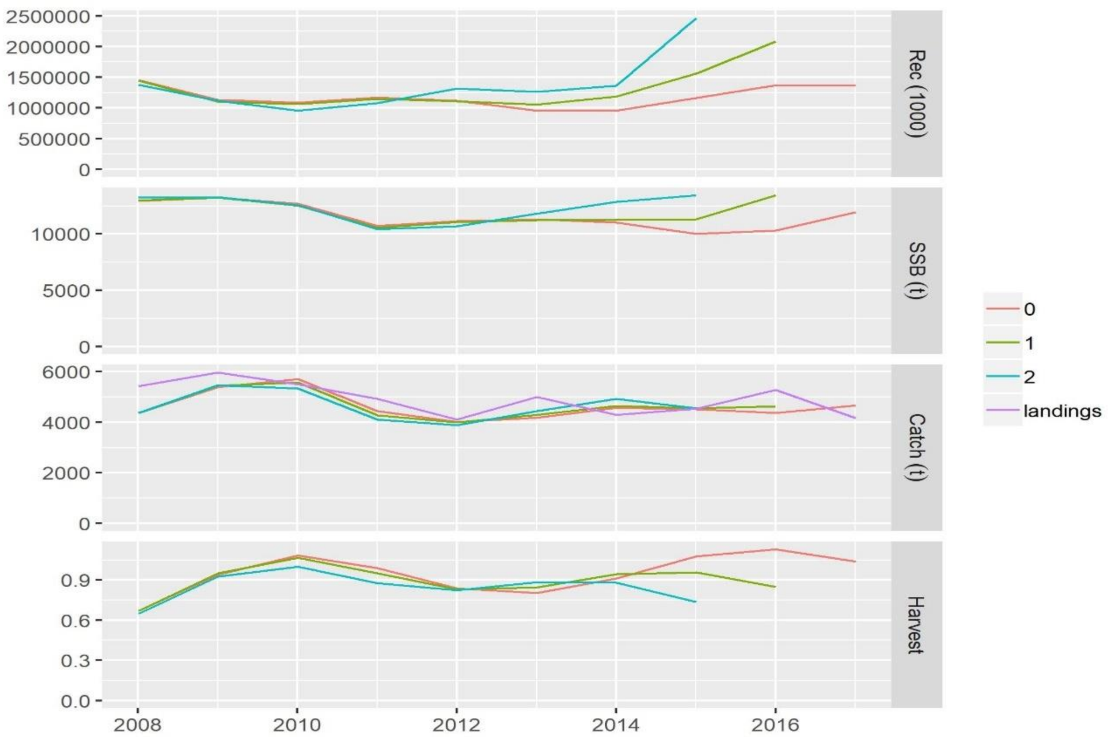


Figure 5.7.2 Spottail mantis shrimp in GSA 17 and 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Summary text on data deficiencies

Issues relevant for the advice

No additional relevant issues for the advice

Reference points

Table 5.7.5 Spottail mantis shrimp in GSA 17 and 18 Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.41	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		Not defined	
	MAP B_{lim}		Not defined	
	MAP F_{MSY}	0.41	$F_{0.1}$ as proxy for F_{MSY}	
	MAP target range F_{lower}	0.28	Based on regression calculation (see section 2)	
	MAP target range F_{upper}	0.57	Based on regression calculation but not tested and presumed not precautionary	

Basis of the assessment

Table 5.7.6 Spottail mantis shrimp in GSA 17 and 18 Basis of the assessment and advice.

Assessment type	Age, Length or Surplus Production Assessment
Input data	DCF commercial data (landings and discards) and scientific survey (SOLEMON), landings data for Croatia (GSA 17) provided by experts.
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 18 - 16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.7.7 Spottail mantis shrimp in GSA 17 and 18 STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landings	STECF discards
2019	F = F_{MSY}		2742 tonnes			

History of the catch and landings

Table 5.7.8 Spottail mantis shrimp in GSA 17 and 18: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2017		Wanted catch				Discards
Catch (t)		Beam trawl 5%%	Gillnets 9%	Trammel nets 5%	Trawlers 81%	t
		176	319	199	2983	466
Effort						
		units				

Table 5.7.9 Spottail mantis shrimp in GSA 17 and 18: History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes.

Year	ITALY GSA 17	ITALY GSA 18	SLOVENIA GSA 17	CROATIA GSA 17	Total landings	Total BMS landings	STECF total landings	Total Effort
2008	3999	917	6		4922			
2009	4529	892	4		5425			
2010	4565	454	5		5024			
2011	3786	352	4		4142			
2012	3105	632	1	2	3739			
2013	2128	2196	0	2	4326			
2014	2806	1004	0	4	3814			
2015	3063	1011	1	7	4082			
2016	3143	929	2	11	4086			
2017	3076	600	1	13	3690			

Summary of the assessment

Table 5.7.10 Spottail mantis shrimp in GSA 17 and 18 Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2008	1458099	1776455	1139743	12958	15260	10656	4365	0.67	0.80	0.54
2009	1129913	1314681	945145	13224	15236	11212	5388	0.94	1.04	0.84
2010	1086219	1251903	920535	12700	14394	11006	5703	1.08	1.21	0.96
2011	1173017	1356451	989583	10730	12136	9324	4445	0.99	1.10	0.88
2012	1115005	1274861	955149	11146	12600	9692	4024	0.84	0.95	0.72
2013	958833	1119211	798455	11300	12826	9774	4181	0.80	0.91	0.70
2014	958635	1114679	802591	11018	12448	9588	4568	0.91	1.01	0.81
2015	1167007	1444833	889181	10028	11336	8720	4513	1.08	1.20	0.95
2016	1367724	1833136	902312	10290	12036	8544	4362	1.13	1.32	0.94
2017	1361547	2395817	327277	11935	15105	8765	4673	1.04	1.43	0.64

Sources and references

6 ASSESSMENTS BY STOCK

ToR 1. Data preparation for the stock assessments:

1. *To compile and provide the most updated information on stock identification and boundaries, length and age composition, growth, maturity, feeding, essential fish habitats and natural mortality.*

2. *To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2017. This should be presented by fishing gear as well as by size/age structure (see Annex II for more details).*

3. *To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2017. This should be described in terms of amount of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size (linear and/or GT), engine power kW, etc.) by Member State/Country and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort and/or capacity baseline (see Annex II for more details).*

4. *To compile and provide indices of abundances and biomass by year and size/age structure for the longest time series available up to and including 2017 by GSA and Country (see Annex II for more details).*

1. Give preference to models that allow estimation of uncertainty, in line with the recommendations of STECF EWG 17-07.

2. To envision alternative stock assessments for the potential conditioning of operating models in the context of future MSEs.

ToR 2. *To assess trends in historic and recent stock parameters on fishing mortality, stock biomass, spawning stock biomass, and recruitment. Different assessment models should be applied as appropriate, including retrospective analyses. The selection of the most reliable assessment shall be explained. Assumptions and uncertainties shall be specified.*

The stock assessments performed in EWG 17-15 and 18-xx will constitute the basis for the preparation of the demersal Adriatic EU MAP. The MAP will require an extensive management strategy evaluation (MSE) in line with the work performed in STECF 16-21 and STECF 15-09. Since the MSEs, encoded in the Fisheries Libraries in R (FLR), rely on established routines where uncertainty and risk play an important role, it is priority for the EWG to:

1. *Give preference to models that allow estimation of uncertainty, in line with the recommendations of STECF EWG 17-07.*

2. *To envision alternative stock assessments models or model configurations for the potential conditioning of operating models in the context of future MSEs.*

ToR 3. *To estimate candidate MSY point-value, MSY range values and conservation reference points (precautionary and limit) in terms of fishing mortality and stock biomass. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.*

ToR 4. *To provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, inter alia: zero catch, the status quo fishing mortality, and target to F_{MSY} (including the ranges) or other appropriate* ***proxy by 2020****. In particular, on the basis of the average commercial catch rates, estimate the level of fishing effort exerted by the different fleets which is commensurate with the short- and medium-term forecasts of the proposed scenarios.*

6.1 HAKE IN GSA 17-18

ToR 7. *Extra model exploration should be dedicated to the assessment of Mediterranean hake (Merluccius merluccius) in GSA 17-18. Make use of the data emerging from the DCF/DCRF and any additional data as deemed necessary and carry out the following tasks:*

1. *Identify potential assessment models to be applied given the data at hand.*
2. *Apply potential models from past assessments, including SS3, XSA and a4a.*
3. *Select the best final model to be used, based on a thorough analysis of model diagnostics and investigating, the consistency of results among models explaining, when necessary, any inconsistencies.*
4. *Calculate reference points, in particular F_{MSY}, B_{PA} and $B_{LIM.}$*
5. *Provide a quantitative advice on the status of the stocks based on the outcomes of the chosen models with respect to the calculated reference points.*
6. *The identification of all outstanding problems associated to the assessment(s) of a resource (including on data, assumptions and methodologies).*

This section contains the summary of the exploration of hake in GSA 17-18, and presents two assessments, SS3 and 4a4 based on very similar overall assumptions. One assessment has been selected and forms the basis of advice, however, the state of vthe stock in 2017 is almost identical in the two methods. In addition Section 6.6 provides a summary of the diagnostic approach used here for evaluating the SS3 based assessment presented here.

6.1.1 STOCK IDENTITY AND BIOLOGY

The stock of European hake was assumed to be constrained within the boundaries of the whole Adriatic Sea (GSA 17-18) (Figure 6.1.1.1), as suggested by the genetic results of the MAREA StockMed project that shows a common sub-population of hake throughout the Adriatic Sea. However, that project identifies two distinct stock units in the Adriatic Sea, uncorrelated with the GSA units (Fiorentino et al., 2014). For this analysis the two stocks are assumed combined.

The species depth distribution (Figure 6.1.1.2) ranges between a few meters in the coastal area down to 800 m in the South Adriatic Pit (Kirinčić and Lepetić, 1955; Ungaro et al., 1993), though it is most abundant at depths between 100 and 200 m, where the catches are mainly composed of juveniles (Bello et al., 1986; Vrgoč, 2000). In the northern and central part of the Adriatic Sea adults are mainly caught at depths of 100 to 150 m (Vrgoč et al., 2004), whereas in the south Adriatic the largest individuals are caught in waters deeper than 200 m and medium-sized fish appear in waters not deeper than 100 m (Ungaro et al., 1993).

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data and geostatistical methods. This species presents the greatest abundance in the central Adriatic Sea in water deeper than 100 meters, whereas the greatest biomass is found in the eastern part of the Adriatic Sea, where the biggest sizes individuals are concentrated (Piccinetti et al., 2012). Nursery areas are located in the central Adriatic Sea, off Gargano promontory and in the southern part of Albanian coasts (Frattini and Paolini, 1995; Lembo et al., 2000; Carlucci et al., 2009) (Figure 6.1.1.3), whereas the spawning grounds are located among the Croatian channels (Figure 6.1.1.4).

European hake can grow to 107 cm (Grubišić, 1959) total length. The observed maximum lengths of European hake in the Adriatic were 93.5 cm for females and 66.5 cm for males both registered during MEDITS samplings. In the commercial sampling also a female of 93.5 cm length was observed in 2009. However, its usual length in trawl catches is from 10 to 60 cm. This is a long-lived species, it can live more than 20 years. In the Adriatic, however, the exploited stock by number is mainly composed of 0, 1 and 2 year-old individuals.

Females attain larger size than males, which grow more slowly after maturation at the age of three or four years. Consequently, the proportion of males in the population is higher in the lower length classes and proportion of females is higher for greater lengths. In the central and northern Adriatic, females already start dominating the population at lengths of about 30 to 33 cm. In trawl catches at lengths over 38 to 40 cm, almost all the specimens are females (Vrgoč, 2000). The growth parameters assumed for this study are showed in Table 6.1.1.1 and they are obtained from the data collected within the DCF in 2017 in GSA 18 (L_{inf}, k and t_0) and GSA 17 (*a* and *b* – length weight parameters)

In the Adriatic Sea, European hake spawn throughout the year, but with different intensities. The spawning peaks are in the summer and winter periods (Karlovac, 1965; Županović, 1968; Županović and Jardas, 1986, Županović and Jardas, 1989; Jukić and Piccinetti, 1981; Ungaro et al., 1993). Hake is a partial spawner. Females spawn usually four or five times without ovarian rests. In females in the pre-spawning stage, fish 70 cm long can contain more than 400,000 oocytes (Sarano, 1986). The earliest spawning in the Pomo/Jabuka Pit occurs in winter in deeper water (up to 200 m). As the season progresses into the spring-summer period, spawning occurs in more shallow waters. The recruitment of young individuals into the breeding stock has two different maxima. The first one is in the spring and the second one in the autumn.

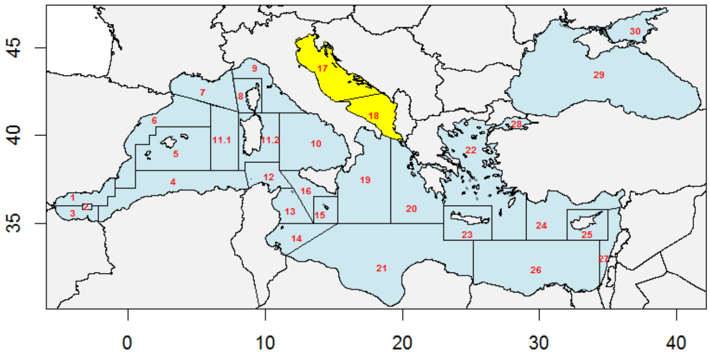


Figure 6.1.1.1 Hake in GSA 17 and 18. Geographical location of GSAs 17-18

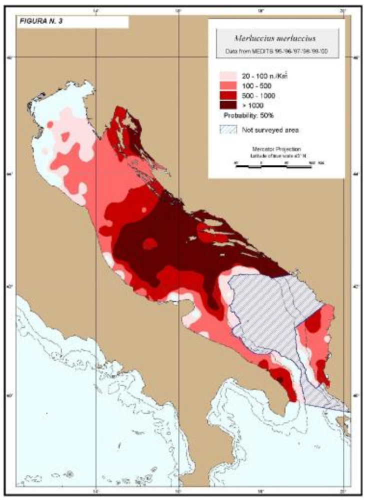


Figure 6.1.1.2 Hake in GSA 17 and 18. Distribution map in the Adriatic Sea from MEDITS Programme (Sabatella and Piccinetti, 2005)

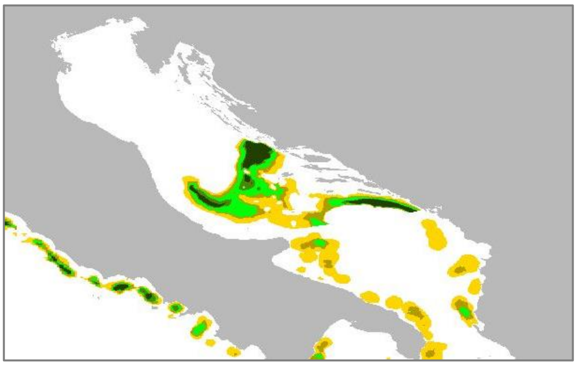


Figure 6.1.1.3 Hake in GSA 17 and 18. Position of peristent nursery in GSAs 17 and 18 from MEDISEH project.

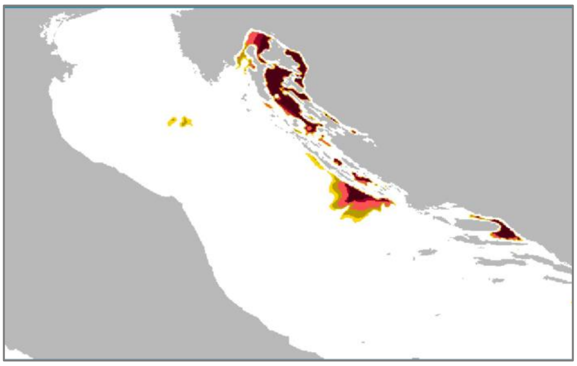


Figure 6.1.1.4 Hake in GSA 17 and 18. Position of peristent spawning area in GSAs 17 and 18 from MEDISEH project

Table 6.1.1.1 Hake in GSAs 17 and 18. Growth and length model parameters.

Sex	L_{inf}	k	t_0	a	b
M	73 cm	0.15	-0.741	0.0057	3.081
F	111 cm	0.10	-0.717	0.0094	2.937

Table 6.1.1.2 Hake in GSAs 17 and 18. Proportion of mature specimens at age (maturity) estimated from maturity at length in SS3 (see section 6.1.3.2) and natural mortality vector by age. Natural mortality was estimated from growth parameters given in Table 6.1.1.1 using the Chen & Watanabe methodology.

Age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
Maturity estimated SS3	0	0.0	0.109	0.676	.943	1	1	1	1	1	1
M females	0.873	0.503	0.363	0.291	0.246	0.216	0.150	0.146	0.142	0.138	0.135
M males	0.883	0.525	0.390	0.319	0.276	0.247	0.214	0.205	0.196	0.189	0.183
Time of spawning	1st of January										

6.1.2 DATA

6.1.2.1 CATCH (LANDINGS AND DISCARDS)

The following tables (Tables 6.1.2.1.1, 6.1.2.1.2 and 6.1.2.1.3) summarise the catch data (landings plus discards) included in the DCF database. Most of the landings come from the bottom trawler, followed by longlines and to a lesser extent gillnet fishery and rapido trawls (only Italy GSA 17).

Table 6.1.2.1.1 Hake in GSAs 17 and 18. Catch data included in the DCF database for Italy in GSA 17.

	Landings		**Discards**	
Year	**OTB**	**TBB**	**OTB**	**TBB**
2006	3980	237		
2007	3435			
2008	3037			
2009	2549			
2010	1863			
2011	1460	12		
2012	1777	15		
2013	2192	30		
2014	1789	62	11	
2015	2011		13	
2016	1731		61	
2017	1836	1836	116	

Table 6.1.2.1.2 Hake in GSAs 17 and 18. Catch data included in the DCF database for Italy in GSA 18.

	Landings				Discards			
Year	GNS	GTR	LLS	OTB	GNS	GTR	LLS	OTB
2002	26			2006				
2003	199			2899				
2004	19	21	233	2932				
2005	38	18	452	3275				
2006	30	26	836	4613				
2007	19	18	620	3497				
2008	15	42	551	3640				
2009	8	20	534	3545				152
2010		19	601	3400				78
2011		18	519	3312				100
2012		20	566	2520				177
2013			188	2379				15
2014		0	279	1584				46
2015			427	1614				86
2016	5		492	1672				107
2017	31	3	514	1682				31

Table 6.1.2.1.3 Hake in GSAs 17 and 18. Catch data included in the DCF database Croatia and Slovenia in GSA 17.

		Landings			Discard		
Year	Country	GNS	OTB	LLS	GNS	OTB	LLS
2005	SVN	0	2				
2006	SVN	1	2				
2007	SVN	1	5				
2008	SVN	0	1				
2009	SVN	0	1				
2010	SVN	0	0				
2011	SVN	0	0				
2012	SVN	0	0				
2013	SVN	0	1				
2014	SVN	0	1				
2015	SVN	1	1				
2016	SVN	0	0				
2017	SVN	0	0				
2013	HRV	43	1013			2	
2014	HRV	58	774	61		2	
2015	HRV	54	769	41		1	
2016	HRV	39	585	124		1	
2017	HRV	47	783	90		3	

Bottom trawl and longlines catch data (landings plus discards) are included in the stock assessments models. Specifically, for the less recent years for which no discard estimates are available, a mean discard ratio was applied. Also, the Albanian and Montenegrin included in the GFCM database were considered. For the SS3 model, catch data were included from 1998; the source of this data is FishStatJ. Table 6.1.2.1.4 summarises the catch data included in the assessment divided by fleet.

Table 6.1.2.1 4 Hake in GSAs 17 and 18. Catch data included in the assessment.

Year	ITA_OTB 17	HRV_OTB 17	HRV_LLS 17	ITA_OTB 18	ITA_LLS 18	MNE_OTB 18	ALB_OTB 18
1998	2524	781	62	4942	731	67	340
1999	2516	543	43	2751	407	67	341
2000	2094	487	38	2837	419	65	330
2001	2022	465	37	2812	416	74	380
2002	2310	521	41	2070	267	39	200
2003	3067	384	30	2992	385	75	384
2004	2895	566	45	3025	233	93	473
2005	3835	726	57	3380	452	52	267
2006	4068	768	61	4760	836	55	280
2007	3514	818	65	3609	620	54	275
2008	3102	532	33	3756	551	63	275
2009	2605	734	37	3696	534	56	336
2010	1903	572	40	3478	601	49	280
2011	1469	653	37	3412	519	40	286
2012	1784	796	34	2697	566	42	899
2013	2196	1015	65	2395	188	43	851
2014	1801	776	61	1630	279	44	902
2015	2026	656	56	1700	427	38	914
2016	1792	587	124	1779	492	39	948
2017	1953	786	90	1713	514	39**	940

*Italian data includes Slovenian catch **missing value, it was assumed to be equal at the value of the previous year

6.1.2.2 EFFORT

Hake is a primary species for the Adriatic fishing fleet, specifically it is a target species for the bottom trawl fishery and to a lesser extent for the longline and gill net fisheries. Longlines target mainly bigger individuals, however their activity, together with the gill net activity, are minor compared to the bottom trawl fishery activity. Table 6.1.2.2.1 and Table 6.1.2.2.2 show the fishing effort, respectively the GT days at sea and the nominal effort in kW days, divided by country and for the main gear.

Table 6.1.2.2.1 Hake in GSAs 17 and 18. Fishing effort (GT*days at sea)/fishing gear/year in GSA 17-18 of the gears targeting hake in this area.

Year	Country	GNS	GTR	OTB	TBB	LLS
2002	ITA_GSA 17	9297244		27568094		
2003	ITA_GSA 17	7646003		27486393		
2004	ITA_GSA 17	4476609	1790055	27823853	4232537	
2005	ITA_GSA 17	4980544	1275558	24094431	3812915	
2006	ITA_GSA 17	4315531	1157336	19896811	4946237	
2007	ITA_GSA 17	2538855	1463360	19409042	5231834	
2008	ITA_GSA 17	2451730	893280	20038778	4136346	
2009	ITA_GSA 17	3280887	1079591	18889991	4386154	
2010	ITA_GSA 17	3396375	1261497	18094570	3817491	
2011	ITA_GSA 17	4643321	1508921	16572093	2584717	
2012	ITA_GSA 17	5314329	1505889	14020762	3254187	
2013	ITA_GSA 17	2974353	1654295	12614324	2769675	
2014	ITA_GSA 17	3864370	685426	14435027	3729815	
2015	ITA_GSA 17	2903140	1212643	13847944	3448162	
2016	ITA_GSA 17	3670471	1293819	14195449	3307483	
2017	ITA_GSA 17	1899953	1233550	16508622	3328623	
2002	ITA_GSA 18	1722336		17112022		
2003	ITA_GSA 18	1002933		14530793		
2004	ITA_GSA 18	1457047	433830	14451460		596928
2005	ITA_GSA 18	2035861	515167	13550061		1054068
2006	ITA_GSA 18	1785782	68546	14744610		771767
2007	ITA_GSA 18	1280477	324507	12840209		633034
2008	ITA_GSA 18	894323	1021626	11463435		1260704
2009	ITA_GSA 18	1205076	837252	13878367		884150
2010	ITA_GSA 18	570405	885271	11856268		1263867
2011	ITA_GSA 18	450946	777735	11329443		922942
2012	ITA_GSA 18	395458	541056	9821959		967941
2013	ITA_GSA 18	777758	60158	10511626		452813
2014	ITA_GSA 18	207752	427424	7736320		297350
2015	ITA_GSA 18	1129811	87687	7013616		547767
2016	ITA_GSA 18	1023952	45468	7822985		528362
2017	ITA_GSA 18	152207	232605	11397672		708375
2005	SVN_GSA 17	32630	61277	112663		390
2006	SVN_GSA 17	37046	54215	143526		1101
2007	SVN_GSA 17	53191	122916	183978		189
2008	SVN_GSA 17	79606	120355	198181		79
2009	SVN_GSA 17	83781	121257	200880		786
2010	SVN_GSA 17	103586	128200	207862		341
2011	SVN_GSA 17	93889	171764	188621		456
2012	SVN_GSA 17	148012	166635	153646		666
2013	SVN_GSA 17	118821	241785	113694		211
2014	SVN_GSA 17	112416	195063	99847		625
2015	SVN_GSA 17	124028	188255	101476		220
2016	SVN_GSA 17	114633	160231	110971		78

2017	SVN_GSA 17	132748	123514	107421		56
2012	HRV_GSA 17	2555257	2170478	6878185		810693
2013	HRV_GSA 17	2314382	2342614	7151551		906311
2014	HRV_GSA 17	2485382	2084672	7291600		875824
2015	HRV_GSA 17	2370247	2312695	7112694		792914
2016	HRV_GSA 17	2283105	1960112	6795609		648707
2017	HRV_GSA 17	2296431	2102611	6811898		792684

Table 6.1.2.2.2 Hake in GSAs 17 and 18. Fishing effort (Days at sea)/fishing gear/year in GSA 17-18 of the gear targeting hake in this area.

Year	Country	GNS	GTR	OTB	TBB	LLS
2004	ITA_GSA 17	245401	129028	5324756	1003129	
2005	ITA_GSA 17	262674	80535	5165331	785589	
2006	ITA_GSA 17	216424	79544	4079669	1052912	
2007	ITA_GSA 17	156782	101669	4056776	1096364	
2008	ITA_GSA 17	135113	56788	4082465	843741	
2009	ITA_GSA 17	173403	65074	3830475	1045203	
2010	ITA_GSA 17	190223	66358	3837446	921158	
2011	ITA_GSA 17	236375	79984	3482614	665155	
2012	ITA_GSA 17	259488	78308	3130643	772706	
2013	ITA_GSA 17	167797	64034	2645415	657556	
2014	ITA_GSA 17	233376	45568	2836181	892595	
2015	ITA_GSA 17	139371	55459	2872228	830339	
2016	ITA_GSA 17	178800	59674	3014054	832100	
2017	ITA_GSA 17	106190	70369	3474852	694210	
2004	ITA_GSA 18	67828	32267	2510980		63792
2005	ITA_GSA 18	94644	69435	2354637		77906
2006	ITA_GSA 18	117032	31528	2662179		77753
2007	ITA_GSA 18	70224	45292	2294240		69117
2008	ITA_GSA 18	51447	83968	2039422		107911
2009	ITA_GSA 18	79662	80946	2386555		64941
2010	ITA_GSA 18	57056	79765	2068044		87474
2011	ITA_GSA 18	44943	79593	1900240		76512
2012	ITA_GSA 18	38287	60542	1668749		73446
2013	ITA_GSA 18	78862	8196	1994855		32817
2014	ITA_GSA 18	21679	51077	1463644		38728
2015	ITA_GSA 18	78693	12679	1355193		56854
2016	ITA_GSA 18	88202	5609	1429243		54673
2017	ITA_GSA 18	24212	29561	1821574		72336
2005	SVN_GSA 17	2740	3047	9155		
2006	SVN_GSA 17	2845	2990	12291		
2007	SVN_GSA 17	4710	6824	17413		
2008	SVN_GSA 17	5004	6531	18858		
2009	SVN_GSA 17	4613	7108	18191		
2010	SVN_GSA 17	5566	7554	18235		

2011	SVN_GSA 17	5293	9171	17782		
2012	SVN_GSA 17	7711	8251	15063		
2013	SVN_GSA 17	5627	14843	11960		
2014	SVN_GSA 17	6066	10544	9372		
2015	SVN_GSA 17	5980	10224	9990		
2016	SVN_GSA 17	5360	8431	10534		
2017	SVN_GSA 17	6211	6593	10214		
2012	HRV_GSA 17	161601	126635		1289335	41067
2013	HRV_GSA 17	146238	130299		1373511	43949
2014	HRV_GSA 17	150427	116713		1381570	44581
2015	HRV_GSA 17	144366	128027		1346257	42016
2016	HRV_GSA 17	145114	109194		1231785	36247
2017	HRV_GSA 17	143673	112415		1169370	41489

6.1.2.3 SURVEY DATA

MEDITS survey data are available from the official 2018 Data Call for GSA 17 and for GSA 18 from 1994. All the countries are covered by the survey data. For the present assessment the data from 1998 to 2017 were used.

The MEDITS survey in GSA 17 and 18 is performed by three units: Italy (and Slovenia) GSA 17, Croatia GSA 17 and Italy GSA 18. The information collected by three survey were combined and used together, since there were no specific reasons supporting the use of three separated surveys (see section 3.1).

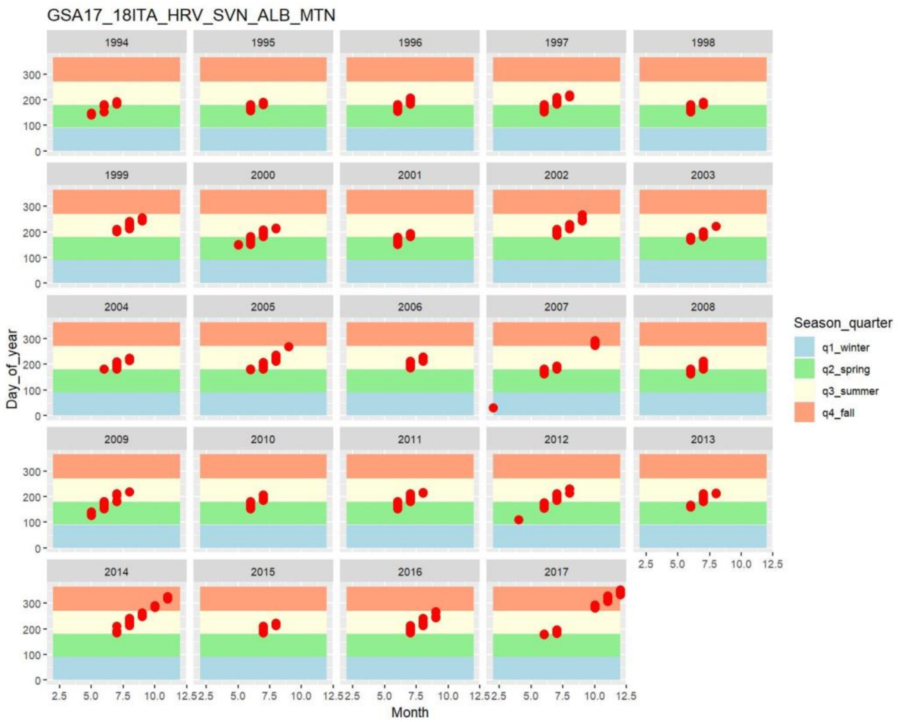


Figure 6.1.2.3. 1 Hake in GSAs 17 and 18. MEDITS survey period over 1994-2017.

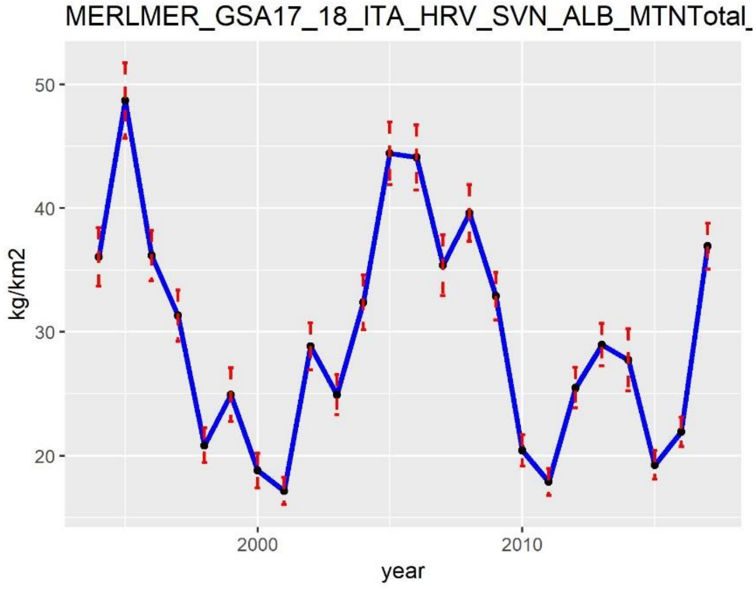


Figure 6.1.2.3. 2 Hake in GSAs 17 and 18. MEDITS biomass (kg/km^2) over 1994-2017.

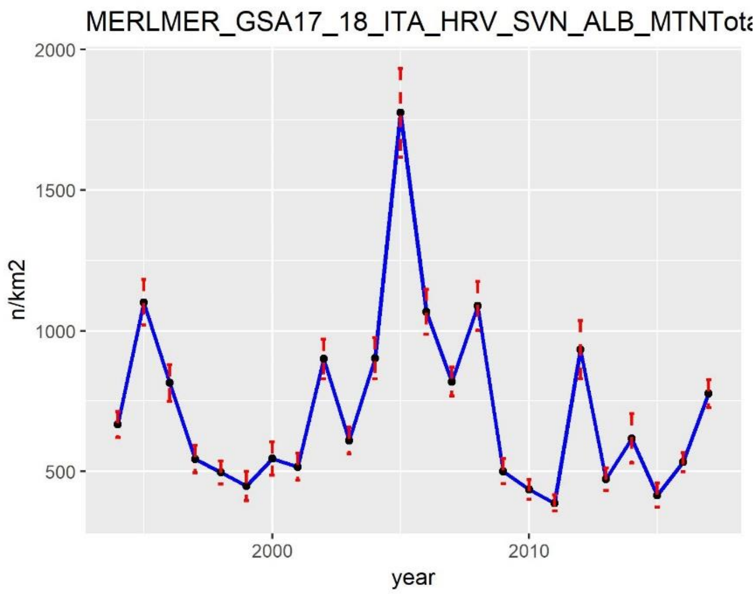


Figure 6.1.2.3. 3 Hake in GSAs 17 and 18. MEDITS abundance (n/km^2) over 1994 - 2017.

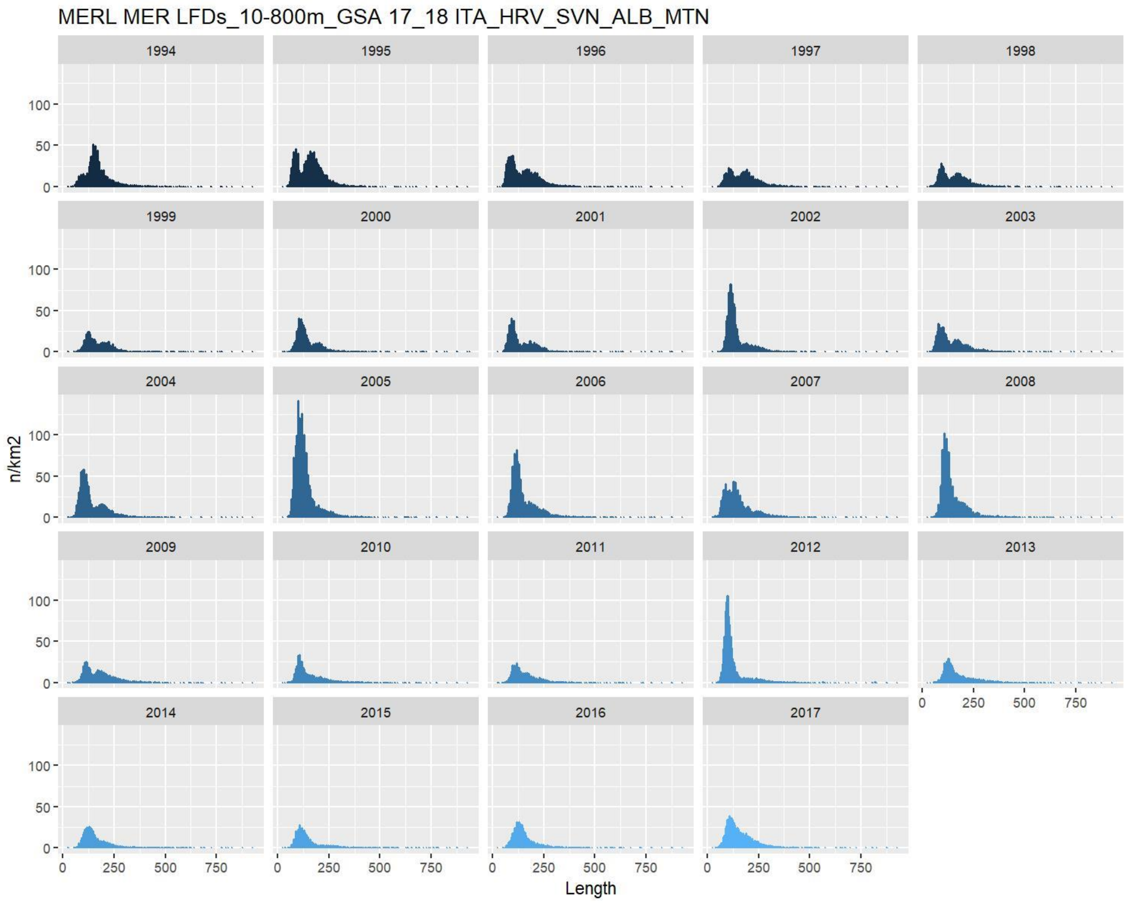


Figure 6.1.2.3. 4 Hake in GSAs 17 and 18. MEDITS Length frequency distribution (TL mm; n/km2).

6.1.3 Stock assessment

Two stock assessment models, a4a and SS3, were fitted and compared.

6.1.3.1 A4A (ASSESSMENT FOR ALL)

A4a is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by fleet. The method was developed within FLR framework.

Input data

The MEDITS indices by length were estimated treating the two GSAs as a unique area, starting from the TC files and re-stratifying the single hauls in the TA files.

The length frequency distributions of all the fleets (available and reconstructed) and the MEDITS LFDs on the whole area were age sliced by means of a deterministic slicing (l2a function available in FLR) using the von Bertalanffy parameters reported in the EU DCF database for GSA18 (Table 6.1.1.1). The LW relationship parameters available on the DCF database were used to calculate the mean weight-at-age. Age slicing and the computation of mean weight-at-age were performed by sex, then age structures were pooled together, and the mean weight-at-age for sex combined was estimated as number weighted average of the mean weight-at-age by sex.

Table 6.1.3.11 Hake in GSAs 17 and 18. VBGF and LW parameters by sex used for the age slicing and the computation of mean weight-at-age.

Sex	L_{inf}	k	t_0	a	b
M	73 cm	0.15	-0.741	0.0057	3.081
F	111 cm	0.10	-0.717	0.0094	2.937

The catch at age matrices are reported in Table 6.1.3.1.2 (commercial) and 6.1.3.1.3 (survey). The overall catch in weight by year is reported in Table 6.1.3.1.4.

The mean weight-at-age is reported in Table 6.1.3.1.5. The natural mortality vector (estimated using the Chen & Watanabe formula) and the maturity at age are reported in Table 6.4.2.6. The M and F before spawning were set equal to 0.0.

Table 6.1.3.1. 2 Hake in GSAs 17 and 18. Commercial catch in numbers at age used in the a4a assessment (thousands).

Year/Age	0	1	2	3	4	5+
2002	81096.7	33014.0	5502.0	1600.1	384.5	334.6
2003	1721.6	40613.2	11511.1	3311.1	471.0	483.5
2004	0.0	32119.4	12234.2	2599.9	460.6	1189.2
2005	14915.8	58862.3	12283.2	3357.0	1241.2	669.8
2006	50337.6	93266.7	13485.4	1661.3	445.9	356.3
2007	42974.4	54218.1	17438.4	2131.8	200.0	338.9
2008	17398.8	51991.5	17455.3	1957.5	590.2	491.4
2009	30290.1	36612.8	15544.5	3835.7	682.5	422.0
2010	24952.2	37186.9	11496.3	2694.5	599.9	531.5
2011	21878.7	31664.9	10705.3	2885.4	773.2	421.2
2012	69870.4	28437.4	9964.6	3170.2	568.2	393.9
2013	21425.5	35315.2	12963.3	2967.0	442.3	285.9
2014	35300.5	26331.2	8872.6	2653.1	398.4	221.5
2015	21468.6	27857.3	11242.9	2643.2	359.5	287.9
2016	24321.9	32084.9	9779.0	2280.7	388.9	257.5
2017	24738.6	34405.0	10819.7	2155.8	476.2	242.9

Table 6.1.3.1.3 Hake in GSAs 17 and 18. MEDITS catch in numbers at age used in the a4a assessment (N/km2).

Year/Age	0	1	2	3	4	5+
2002	717.1	122.8	44.1	7.8	1.2	0.4
2003	428.6	133.2	38.7	7.1	1.1	0.9
2004	653.4	186.6	43.4	9.1	1.6	1.2
2005	1528.5	168.1	51.1	11.4	2.8	0.9
2006	785.6	203.1	59.8	13.4	3.3	1.6
2007	611.3	136.3	53.3	13.4	2.9	1.4
2008	839.7	187.2	42.2	11.9	3.5	2.3
2009	265.7	161.1	56.7	12.4	2.8	1.4
2010	311.4	86.5	26.4	7.1	1.5	1.6
2011	261.9	95.6	21.5	5.1	1.2	1.1

2012	807.9	70.0	39.1	8.3	1.7	1.1
2013	302.4	100.3	47.9	11.9	1.9	1.5
2014	333.9	108.2	27.1	7.1	2.1	1.6
2015	319.2	53.8	29.2	7.7	2.5	2.1
2016	395.9	100.9	26.0	7.1	1.3	0.9
2017	506.9	195.6	54.6	11.7	3.6	1.4

Table 6.1.3.1. 4 Hake in GSAs 17 and 18. Catch in weight by year (tons).

Year	Catch (tons)
2002	5535
2003	7165
2004	7330
2005	8769
2006	10828
2007	8955
2008	8312
2009	7998
2010	6923
2011	6416
2012	6818
2013	6753
2014	5493
2015	5817
2016	5761
2017	6035

Table 6.1.3.1. 5 Hake in GSAs 17 and 18. Individual weight at age for the in the catch and stock (kg).

Year/Age	0	1	2	3	4	5+
2002	0.018	0.060	0.170	0.325	0.606	1.095
2003	0.024	0.078	0.168	0.354	0.528	1.278
2004	0.026	0.082	0.166	0.331	0.618	1.261
2005	0.028	0.063	0.166	0.346	0.586	1.088
2006	0.027	0.064	0.160	0.346	0.578	1.385
2007	0.021	0.072	0.159	0.329	0.569	1.683
2008	0.022	0.069	0.155	0.334	0.609	1.271
2009	0.018	0.071	0.171	0.332	0.604	1.522
2010	0.021	0.066	0.175	0.337	0.592	1.405
2011	0.020	0.069	0.172	0.335	0.584	1.486
2012	0.017	0.070	0.168	0.363	0.610	1.381
2013	0.023	0.068	0.169	0.350	0.595	1.275
2014	0.020	0.066	0.174	0.347	0.589	1.593
2015	0.017	0.071	0.173	0.340	0.600	1.439
2016	0.019	0.070	0.173	0.346	0.585	1.358
2017	0.019	0.070	0.169	0.337	0.598	1.357

Table 6.1.3.1.6 Hake in GSAs 17 and 18. Natural mortality vector and proportion of mature individuals by age.

Age	0	1	2	3	4	5+
M	0.88	0.51	0.37	0.30	0.26	0.22
Maturity	0.00	0.25	0.75	1.00	1.00	1.00

Different combinations of F, q and stock-recruitment sub-models were explored. The list of the sub-models is reported below:

F sub-model:

~ s(age, k = 5) + s(year, k = 8)

~ s(replace(age, age > 4, 4), k = 5) + s(year, k = 8)

~ factor(age) + factor(year)

~ factor(age) + s(year, k = 7)

~ s(age, k = 3) + s(year, k = 7) + s(year, k = 7, by = as.numeric(age == 0))

~ factor(replace(age, age > 4, 4)) + s(year, k = 8)

~ factor(replace(age, age > 4, 4)) + s(year, k = 6, by = as.numeric(age == 0))

~ factor(replace(age, age > 4, 4)) + factor(year)

~ te(age, year, k = c(4,8))

q sub-models:

list(~ s(age, k = 4))

list(~ factor(age))

list(~ factor(replace(age, age>4 ,4)))

list(~ factor(replace(age, age > 3, 3)) + factor(year))

list(~ factor(replace(age, age > 3, 3)) + s(year, k = 4))

list(~ s(replace(age, age > 3, 3), k = 3))

An F_{bar} range between age 1 and 4 was used. The best model (combination of the sub-models in bold) was chosen on the basis of retrospective analysis and residuals.

Results

The F_{bar} time series estimated by a4a varies between 0.92 and 0.60, with most years at about 0.8.,, There is a decrease in Fbar in the last 4 years. Also SSB and recruitment show a slight increase in the last years of the time series (Figure 6.1.3.1.1).

The fishing mortality at age shows the maximum values in age 2 and 3, decreasing over time.

In general, the fitting of the commercial catch at age and the indices at age is quite satisfactory (Figures 6.1.3.1.2 and 6.1.3.1.3).

The residuals are generally small and quite randomly distributed by age (Figure 6.4.3.13), but a signal of a trend (all positive residuals) is shown in the survey in the period 2005-2008. This could be due to the strong recruitment observed in the survey in

2005, which is less apparent in the catch. There is very good internal consistency in age structure in the catch data (Figure 6.1.3.1.9), though the survey data shows less coherence across years and ages (Figure 6.1.3.1.10).

Table 6.1.3.1. 7 Hake in GSAs 17 and 18. Results of the final a4a run: F_{bar} (1-4) overall, SSB, Recruitment and total biomass.

Year	F_{bar} (0-3)	Recruitment (thousands)	SSB (tons)	Total biomass (tons)
2002	0.65	253463	5479	14114
2003	0.79	210008	8207	19840
2004	0.87	266537	8946	21743
2005	0.88	294731	8177	21850
2006	0.85	296893	8843	23007
2007	0.86	279379	10076	22925
2008	0.89	251186	9600	21506
2009	0.92	212998	9839	19625
2010	0.91	212165	8742	17977
2011	0.86	191433	8132	16765
2012	0.83	192880	7840	15628
2013	0.83	198114	7522	16482
2014	0.84	171138	7873	15716
2015	0.81	199118	7552	15101
2016	0.72	229250	7431	16372
2017	0.60	248303	8391	18520

Table 6.1.3.1. 8 Hake in GSAs 17 and 18. Results of the final a4a run: F-at-age.

Year	0	1	2	3	4	5+
2002	0.09	0.68	0.82	0.73	0.39	0.39
2003	0.11	0.82	0.99	0.88	0.47	0.47
2004	0.12	0.91	1.10	0.97	0.52	0.52
2005	0.12	0.91	1.11	0.98	0.52	0.52
2006	0.12	0.89	1.07	0.95	0.50	0.50
2007	0.12	0.89	1.08	0.95	0.51	0.51
2008	0.12	0.93	1.12	1.00	0.53	0.53
2009	0.13	0.96	1.16	1.03	0.55	0.55
2010	0.12	0.94	1.14	1.01	0.54	0.54
2011	0.12	0.89	1.08	0.96	0.51	0.51
2012	0.11	0.86	1.04	0.92	0.49	0.49
2013	0.11	0.86	1.04	0.92	0.49	0.49
2014	0.12	0.87	1.06	0.94	0.50	0.50
2015	0.11	0.84	1.02	0.90	0.48	0.48
2016	0.10	0.75	0.90	0.80	0.43	0.43
2017	0.08	0.62	0.75	0.67	0.35	0.35

Table 6.1.3.1.9 Hake in GSAs 17 and 18. Results of the final a4a run: Stock numbers-at-age.

Year	0	1	2	3	4	5+
2002	253463	75917	15435	3505	1114	510
2003	210008	96100	23122	4683	1253	861
2004	266537	78184	25499	5936	1443	1041
2005	294731	98062	18970	5873	1662	1163
2006	296893	108353	23659	4340	1635	1317
2007	279379	109536	26851	5591	1243	1400
2008	251186	103029	27055	6320	1596	1255
2009	212998	92147	24458	6069	1729	1319
2010	212165	77815	21202	5283	1605	1384
2011	191433	77694	18226	4679	1424	1374
2012	192880	70571	19139	4276	1332	1325
2013	198114	71431	17997	4682	1263	1283
2014	171138	73344	18168	4389	1379	1228
2015	199118	63246	18408	4360	1274	1247
2016	229250	73877	16354	4580	1307	1227
2017	248303	86145	21029	4571	1522	1302

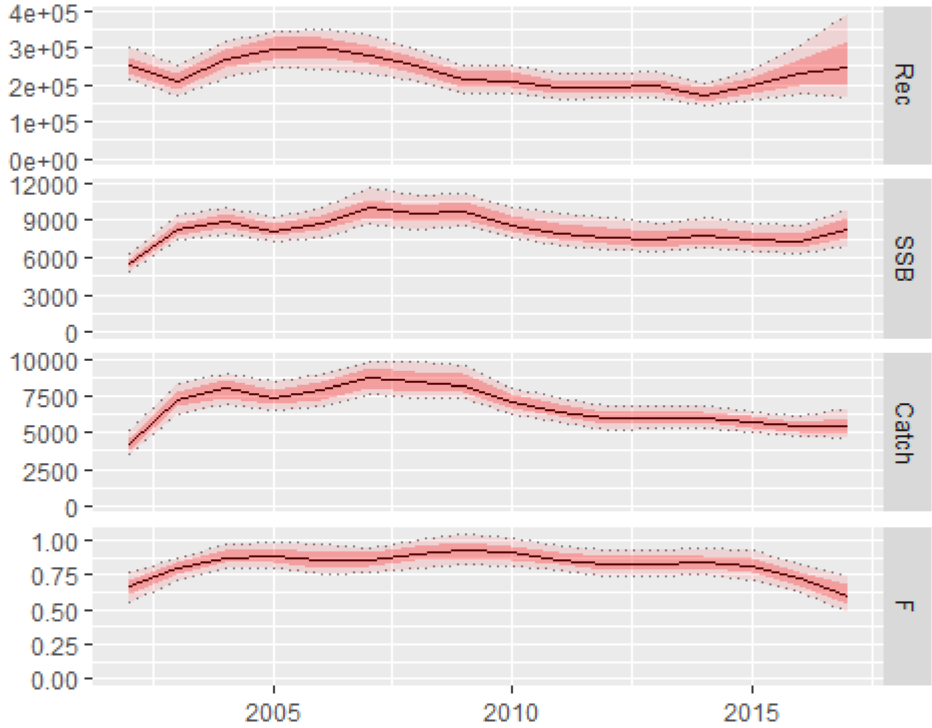


Figure 6.1.3.1.1 Hake in GSAs 17 and 18. Summary of the results.

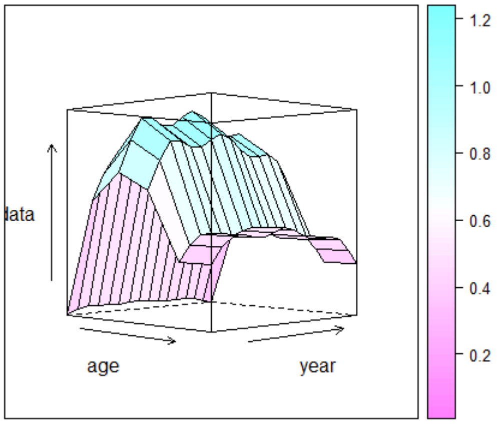


Figure 6.1.3.1.2 Hake in GSAs 17 and 18. Fishing mortality by age and year.

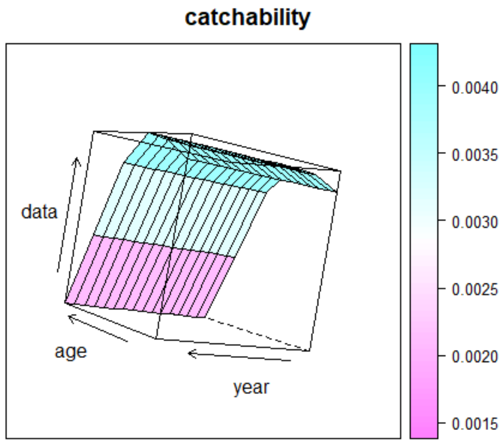


Figure 6.1.3.1.3 Hake in GSAs 17 and 18. Catchability (right) by age and year.

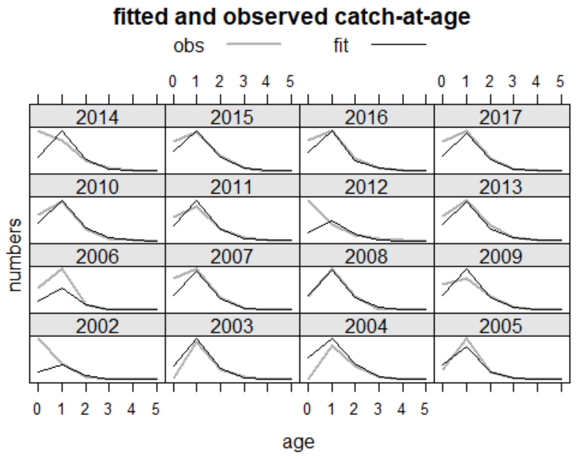


Figure 6.1.3.1.4 Hake in GSAs 17 and 18. Comparison between observed and fitted catch at age.

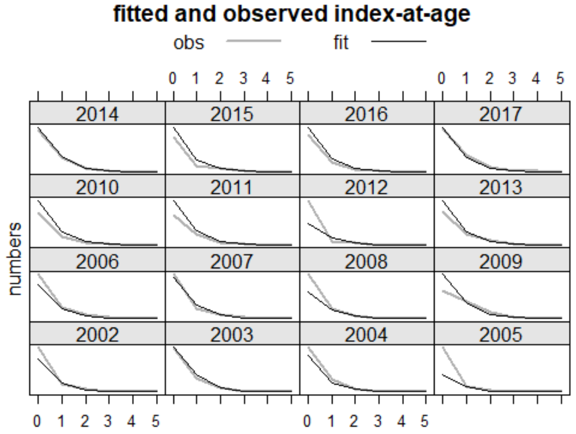


Figure 6.1.3.1. 5 12 Comparison between observed and fitted index at age.

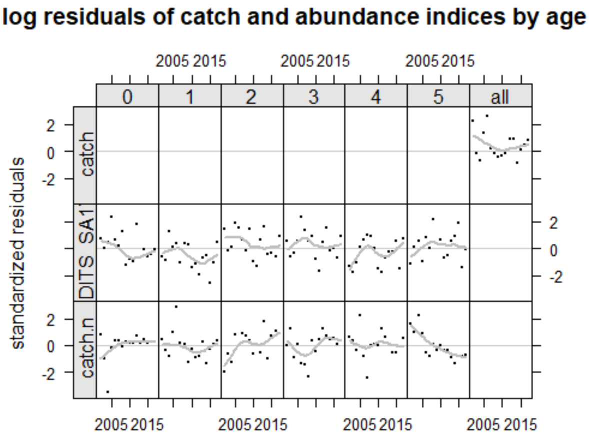


Figure 6.1.3.1.5 Hake in GSAs 17 and 18. Log-residuals of catch and abundance indices by age.

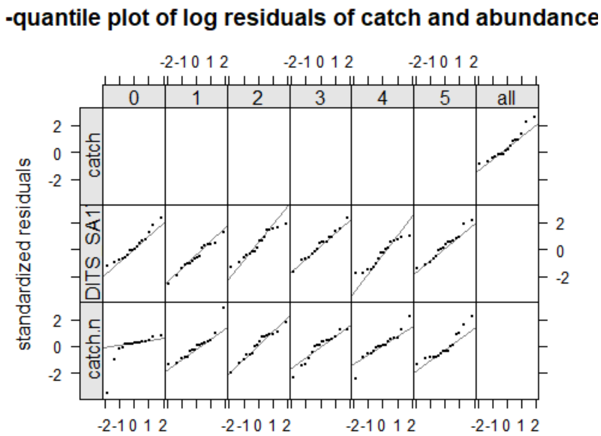


Figure 6.1.3.1.6 Hake in GSAs 17 and 18. Qq-plot of catch and abundance indices by age.

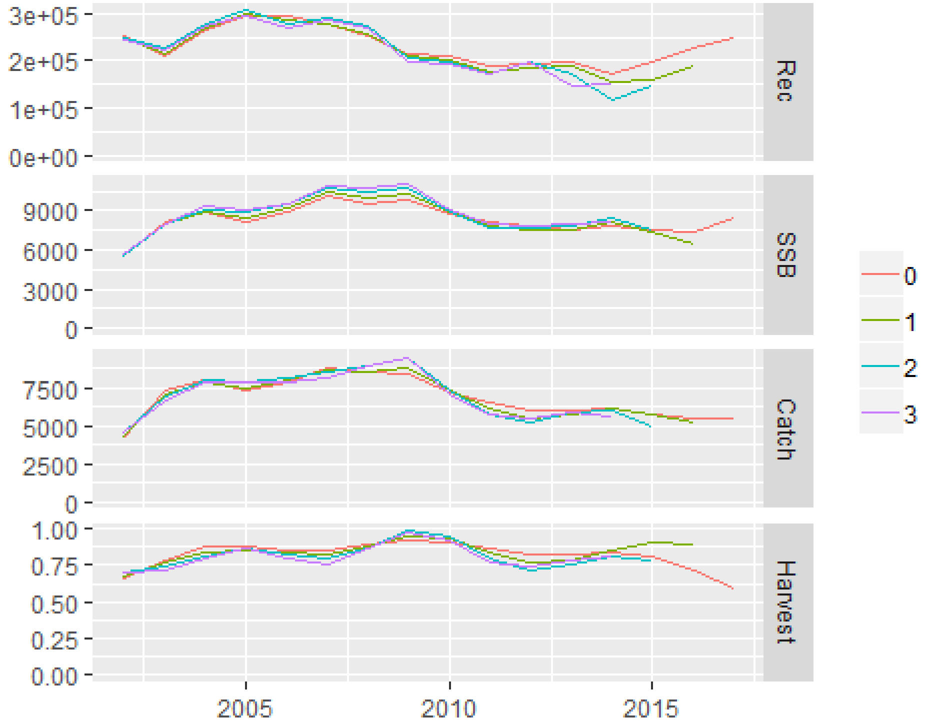


Figure 6.1.3.1.7 Hake in GSAs 17 and 18. Retrospective analysis.

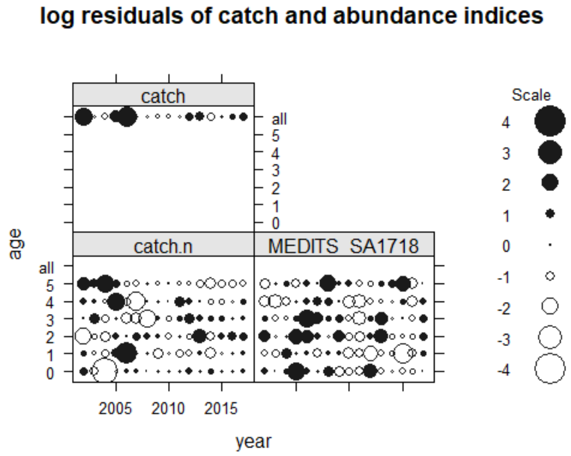


Figure 6.1.3.1.8 Hake in GSAs 17 and 18. Bubble plot of the residuals.

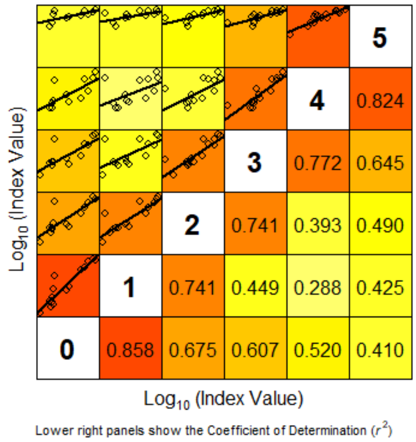


Figure 6.1.3.1.9 Hake in GSAs 17 and 18. Internal consistency in the catches.

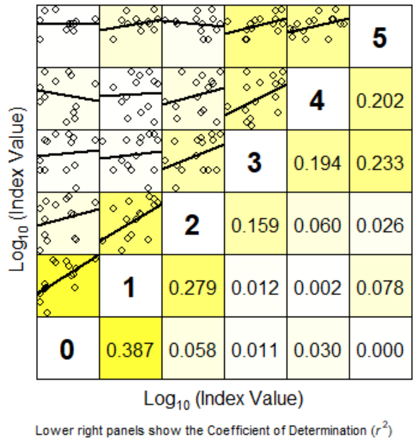


Figure 6.1.3.1.10 Hake in GSAs 17 and 18. Internal consistency in the index.

6.1.3.2 Stock Synthesis

Stock Synthesis 3 (SS3; Methot and Wetzel, 2013) provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. It is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analysed. It uses forward projection of population as in the "statistical catch-at-age" (hereafter SCAA) approach. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Some SS3 features include ageing error, growth estimation, spawner-recruitment relationship, movement between areas. The ADMB C++ software in which SS is written searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian methods. The F at age has been estimated from the Z at age estimated by the model (subtracting M at age used in input); then, the F_{bar} has been estimated as average of the selected ages.

This assessment was carried out using the length-based approach, thus the abundance at age for each fleet is included by length. However, using the growth function, the model is able to estimate abundance and biomass by length and age classes. In this case the model was developed considering two sexes, thus a different growth curve was assigned for males and females underlining the characteristic sexual dimorphism of this species. Selectivity by fleet has been generated as length-specific. F_{bar} was calculated considering age from 1 to 5. The SS3 analyses have been carried out considering the following 8 fleets: 7 fishing fleets and 1 surveys. The MEDITS survey is carried out in three different units (Italy GSA 17, Croatia GSA 17 and GSA 18). However, considering that the standard procedure is followed for all three surveys , it was preferred to use this information as a single combined index by length using the ad-hoc script.

Fishing fleet

1) Italian bottom trawl GSA 17, including also Slovenian data (catch and LFDs)
2) Croatian bottom trawl (catch and LFDs)
3) Croatian longlines (catch and LFDs)
4) Italian bottom trawl GSA 18 (catch and LFDs)
5) Italian longlines GSA 18 (catch and LFDs
6) Montenegrin bottom trawl and nets (catch and LFDs
7) Albania bottom trawls (only catch data)

Survey

1) MEDITS survey (index N/km^2 and LFDs)

Input data and fitting of the model

Figure 6.1.3.2.1 summarises the data included in the SS3 model. Specifically, the catch data (Fig. 6.1.3.2.2) goes from 1998 to 2017. Italian, Slovenian and Croatian catch data are included in the DCF database since 2002 for ITA_OTB_18, since 2004 for ITA_LLS_18, since 2006 for ITA_OTB_17 and since 2013 for Croatia. For the non EU countries, the data included in the GFCM were considered, and Albania also provided updated information to the EWG.

SS3 allows to assign different selectivity by gear (Fig. 6.1.3.2.3.) In this case, the double normal selectivity was the best performing model for all the fleets. It was preferred to specify a selectivity curve for each fleet, except for the Albanian bottom trawl. For this fleet no length frequency distributions were available, thus it was assumed a selectivity curve equal to that one of the Italian bottom trawls in GSA 18. For the two longlines fleets a sex specific selectivity was set, since they clearly showed a different selection pattern, for all other fleets selectivity at age was not sex specific.

The von Bertalanffy and L-W parameters assumed for this model are those used in the a4a model (see Table 6.1.3.1.3). Figure 6.1.3.2.4 shows the resulting growth by sex. Natural mortality corresponds to the Chen & Watanabe methodology (Table 6.1.1.2), as used in the a4a model.

Figure 6.1.3.2.5 summarises the observed length frequency distribution (LFD) by fleet, also showing the fitting of the model. While figure 6.1.3.2.6 summarises the Pearson residuals for the LFDs by fleet and year.

Figure 6.1.3.2.7 shows the index by year from the MEDITS survey with the model fitting; residuals are also reported (Fig. 6.1.3.2.8).

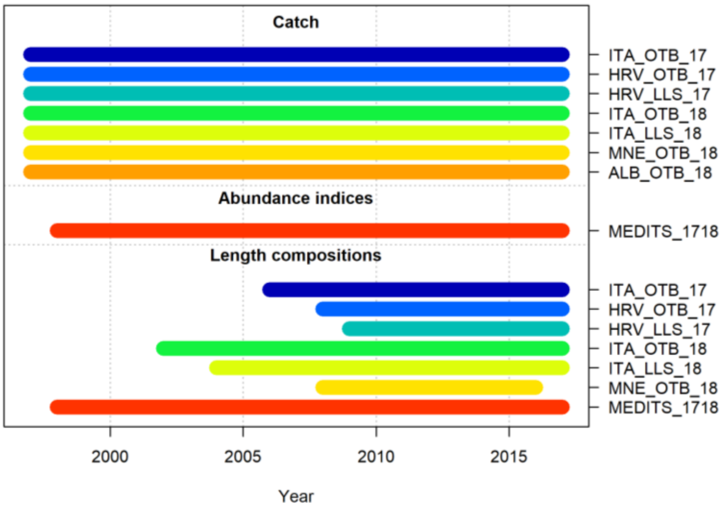


Figure 6.1.3.2. 1 Hake in GSAs 17 and 18. Summary of the input included in the SS3 model.

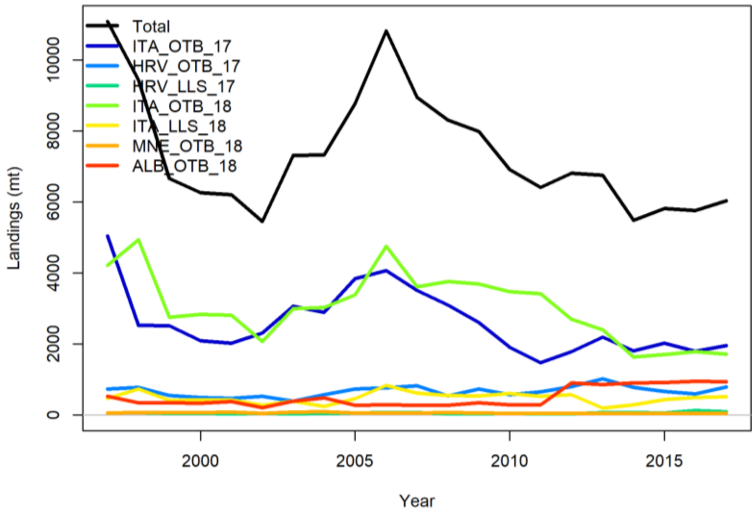


Figure 6.1.3.2. 2 Hake in GSAs 17 and 18. Catch data by country, gear and year.

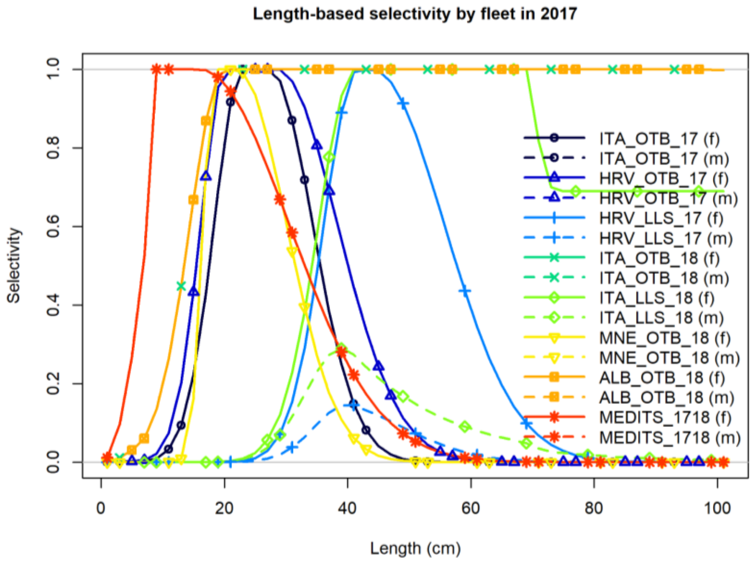


Figure 6.1.3.2. 3 Hake in GSAs 17 and 18. Selectivity by fleet and sex.

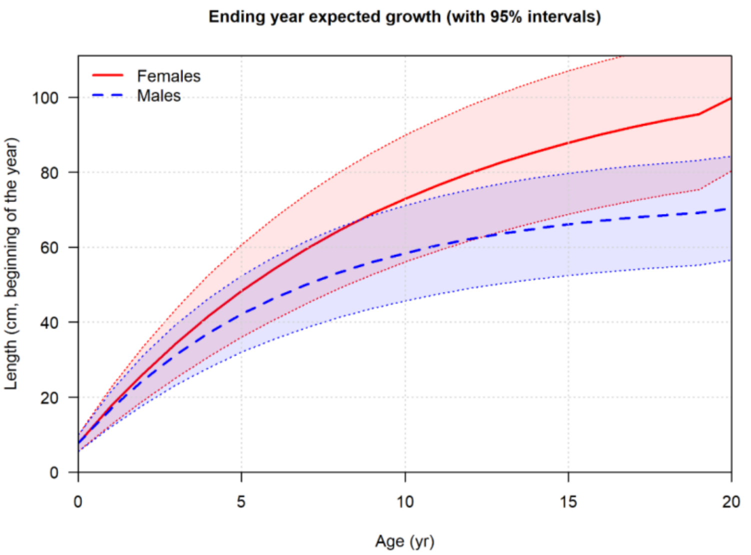


Figure 6.1.3.2. 4 Hake in GSAs 17 and 18. The growth curve assumed in the SS model for females (red) and males (blue).

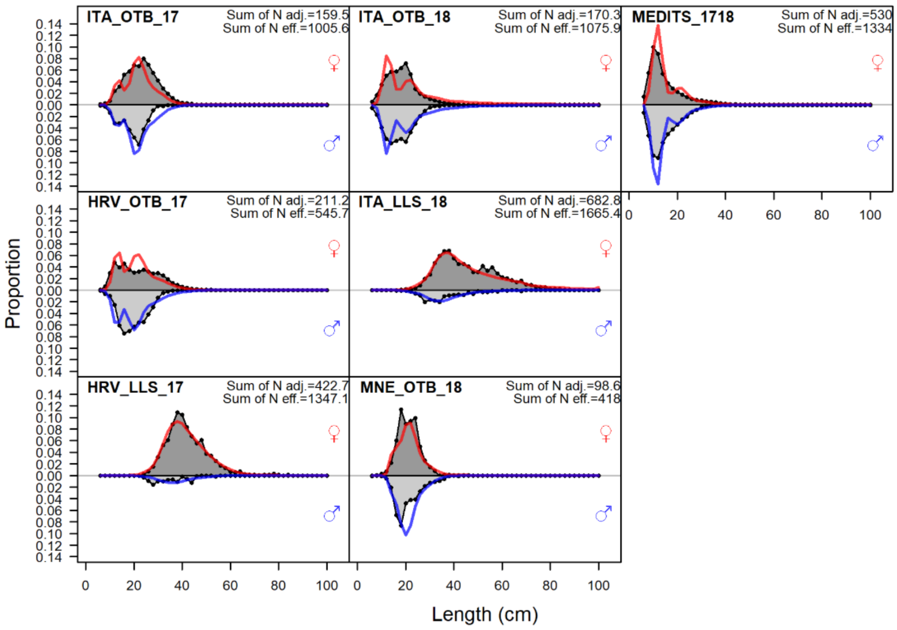


Figure 6.1.3.2. 5 Hake in GSAs 17 and 18. Summary of the observed length frequency distribution (grey area) by fleet and the fitting of the model (blue line for the male individuals and red line for the female individuals).

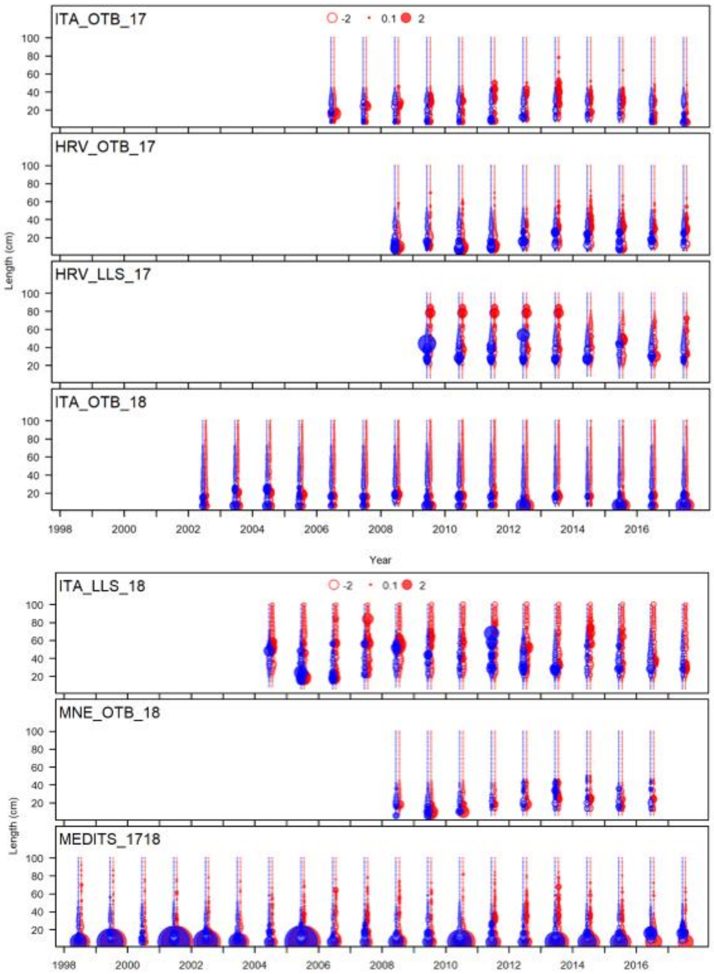


Figure 6.1.3.2. 6 Hake in GSAs 17 and 18. Summary of the Pearson residuals for the LFDs by fleet and year. Closed bubbles are positive residuals (observed > expected) and

open bubbles are negative residuals (observed < expected). Blue bubbles are used for males, red for females.

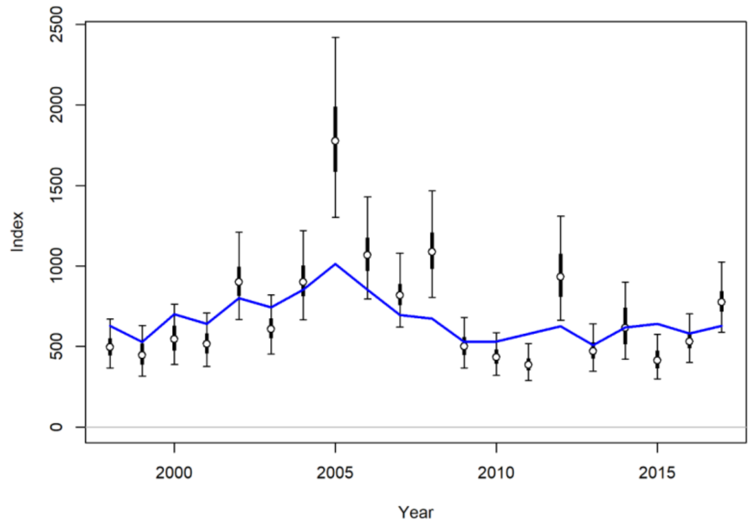


Figure 6.1.3.2. 7 Hake in GSAs 17 and 18. Abundance index (N/Km2) and fitting of the model (blue line) for the MEDITS survey.

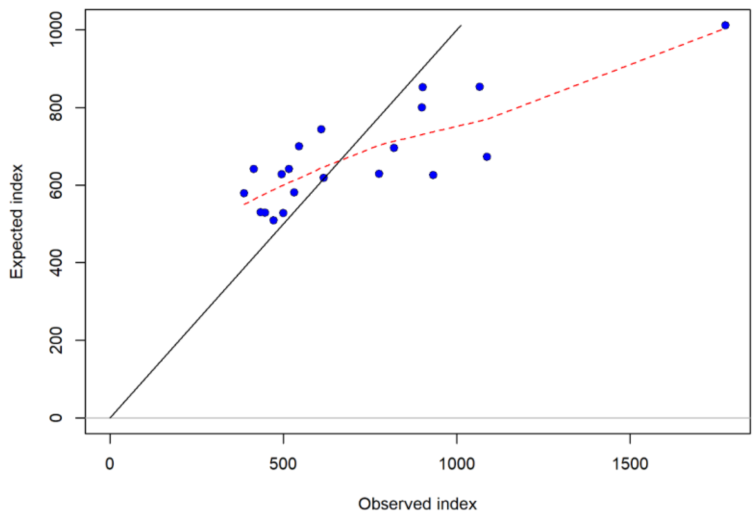


Figure 6.1.3.2. 8 Hake in GSAs 17 and 18. Residuals by year for the MEDITS survey.

Results

The total biomass estimated by the SS3 show a generally increasing trend to 2006, then decreases continuosly to 2014, when the lowest biomass is recorded (18,009 tonnes). The value for the 2017 is equal at 18,523 tonnes. The spawning stock biomass follows a similar trend recording the highes value in 2005 (15,060 tonnes) and lowest value in 2016 (8,660 tonnes). Recruitment has a fluctuating trends with an important peak in 2005 (269,732 thousands). At the beginning of the time series, the fishing mortality followed a decreasing trend to 2002 (0.34 yr^{-1}), to increase to 0.54 yr^{-1} in 2006; after this year the trend appears more stable, describing a slightly decrease in the most recent years (F equal at 0.42 yr^{-1} in 2016 and 0.45 yr^{-1} in 2017

Results are summarised by tables (Tables 6.1.3.2.1, 6.1.3.2.2, 6.1.3.2.3 and 6.1.3.2.4) and figures (Figs. 6.1.3.2.9, 6.1.3.2.10 and 6.1.3.2.11).

Table 6.1.3.2. 1 Hake in GSAs 17 and 18. Total biomass (in tonnes) spawning stock biomass (SSB, in tonnes) and recruitment (in thousands) resulting from the SS3 model.

Year	Total biomass	SSB	Recruitment	$F_{bar(1-4)}$
1998	26994	13397	132046	0.47
1999	24888	12766	119859	0.41
2000	24610	13216	190382	0.42
2001	24929	13162	145587	0.37
2002	25682	13200	207221	0.34
2003	27765	14248	171695	0.41
2004	28383	14565	219951	0.41
2005	29526	15060	269732	0.49
2006	29892	14939	201564	0.54
2007	27747	13911	161591	0.50
2008	26278	13668	169402	0.50
2009	24661	13090	119846	0.52
2010	22522	12183	135316	0.48
2011	21040	11288	149484	0.45
2012	20276	10409	163043	0.50
2013	19262	9574	119809	0.55
2014	18009	9105	169126	0.48
2015	18143	8939	161771	0.47
2016	18281	8660	134682	0.42
2017	18523	8670	160606	0.45

Table 6.1.3.2. 2 Hake in GSAs 17 and 18. Total fishing mortality (Total F) by year estimated by the model. F by fleet is also reported.

Year	ITA_OTB_17	HRV_OTB_17	HRV_LLS_17	ITA_OTB_18	ITA_LLS_18	MNE_OTB_18	ALB_OTB_18
1998	0.22	0.05	0.01	0.13	0.04	0.01	0.01
1999	0.25	0.04	0.00	0.07	0.02	0.01	0.01
2000	0.25	0.04	0.00	0.08	0.02	0.01	0.01

2001	0.22	0.04	0.00	0.08	0.02	0.01	0.01
2002	0.22	0.04	0.00	0.05	0.01	0.00	0.01
2003	0.27	0.03	0.00	0.07	0.02	0.01	0.01
2004	0.26	0.04	0.01	0.07	0.01	0.01	0.01
2005	0.32	0.05	0.01	0.08	0.02	0.01	0.01
2006	0.32	0.05	0.01	0.11	0.04	0.01	0.01
2007	0.30	0.05	0.01	0.09	0.03	0.01	0.01
2008	0.32	0.04	0.00	0.10	0.03	0.01	0.01
2009	0.30	0.06	0.00	0.11	0.03	0.01	0.01
2010	0.26	0.06	0.01	0.11	0.04	0.01	0.01
2011	0.21	0.07	0.01	0.12	0.04	0.01	0.01
2012	0.24	0.08	0.01	0.10	0.04	0.01	0.01
2013	0.29	0.10	0.01	0.09	0.01	0.01	0.01
2014	0.26	0.08	0.01	0.06	0.02	0.01	0.01
2015	0.25	0.06	0.01	0.06	0.03	0.01	0.01
2016	0.20	0.05	0.02	0.06	0.04	0.01	0.01
2017	0.22	0.07	0.02	0.06	0.04	0.01	0.01

Table 6.1.3.2. 3 Hake in GSAs 17 and 18. Stock numbers at age estimated by SS3.

	Age										
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1998	132046	77023	28127	10946	5239	3025	1918	1306	902	630	1537
1999	119859	47941	26761	10987	5197	2886	1810	1239	858	601	1477
2000	190382	44800	17241	10893	5598	3125	1896	1285	895	628	1551
2001	145587	71051	16090	7012	5540	3354	2044	1340	924	651	1619
2002	207222	54784	26984	6926	3686	3373	2211	1450	966	674	1691
2003	171695	79163	21375	11944	3779	2345	2330	1645	1097	740	1847
2004	219950	64418	28606	8746	6154	2300	1557	1669	1198	808	1944
2005	269732	82307	23174	11686	4503	3749	1531	1119	1220	886	2075
2006	201564	99487	26832	8519	5620	2643	2440	1082	807	892	2210
2007	161591	72801	30995	9363	3844	3077	1603	1608	728	551	2168

2008	169402	59194	23729	11360	4415	2192	1942	1099	1125	517	1977
2009	119846	61835	19104	8626	5337	2508	1375	1320	761	790	1793
2010	135316	43371	19640	6832	3969	2970	1545	920	902	527	1831
2011	149484	49326	14615	7448	3233	2222	1822	1026	623	619	1659
2012	163043	54582	17381	5803	3597	1815	1359	1204	691	425	1593
2013	119809	58973	18173	6504	2690	1970	1092	887	803	467	1402
2014	169126	42870	18061	6283	2918	1476	1207	731	608	559	1334
2015	161771	61937	14339	6821	3004	1673	935	832	515	435	1386
2016	134682	59521	21212	5522	3284	1717	1051	637	579	364	1319
2017	160606	50059	22048	8815	2750	1882	1069	708	438	404	1209

Table 6.1.3.2. 4 Hake in GSAs 17 and 18. Fishing mortality (F) at age estimated by SS3.

	Age										
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Mean Age 10 - 20**
1998	0.14	0.54	0.56	0.44	0.34	0.28	0.26	0.25	0.24	0.23	0.23
1999	0.11	0.51	0.52	0.37	0.25	0.19	0.17	0.15	0.15	0.14	0.14
2000	0.11	0.51	0.52	0.37	0.25	0.20	0.17	0.16	0.15	0.15	0.14
2001	0.10	0.45	0.47	0.34	0.24	0.19	0.17	0.16	0.15	0.15	0.14
2002	0.08	0.43	0.44	0.30	0.19	0.14	0.12	0.11	0.10	0.10	0.10
2003	0.10	0.50	0.52	0.36	0.24	0.18	0.16	0.15	0.14	0.14	0.13
2004	0.10	0.51	0.52	0.36	0.24	0.18	0.15	0.14	0.14	0.13	0.13
2005	0.12	0.61	0.62	0.43	0.28	0.20	0.17	0.16	0.15	0.14	0.14
2006	0.14	0.65	0.68	0.49	0.35	0.27	0.24	0.22	0.21	0.21	0.20
2007	0.13	0.61	0.63	0.45	0.31	0.23	0.20	0.18	0.18	0.17	0.16
2008	0.13	0.62	0.64	0.45	0.31	0.24	0.21	0.19	0.19	0.18	0.18
2009	0.14	0.63	0.65	0.47	0.33	0.26	0.22	0.21	0.20	0.20	0.19
2010	0.13	0.57	0.59	0.45	0.32	0.26	0.23	0.22	0.21	0.20	0.20
2011	0.13	0.53	0.55	0.42	0.32	0.26	0.24	0.22	0.22	0.21	0.20
2012	0.14	0.59	0.61	0.47	0.34	0.28	0.25	0.23	0.22	0.22	0.21
2013	0.15	0.67	0.69	0.50	0.34	0.26	0.22	0.21	0.20	0.19	0.19

2014	0.13	0.58	0.60	0.44	0.30	0.23	0.19	0.18	0.17	0.16	0.16
2015	0.12	0.56	0.58	0.43	0.30	0.24	0.20	0.19	0.18	0.18	0.17
2016	0.11	0.48	0.50	0.39	0.30	0.24	0.22	0.20	0.19	0.18	0.18
2017	0.12	0.53	0.55	0.42	0.30	0.24	0.21	0.20	0.19	0.18	0.17

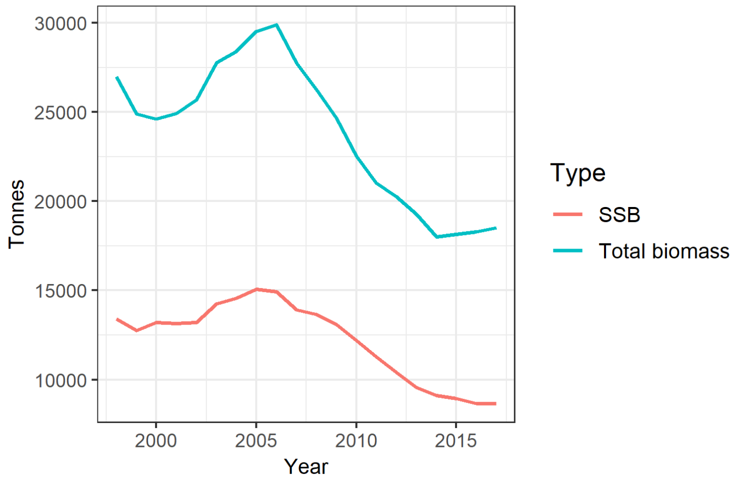


Figure 6.1.3.2. 9 Hake in GSAs 17 and 18. Total biomass (light blue) and spawning stock biomass (red) by year estimated by the SS3 model.

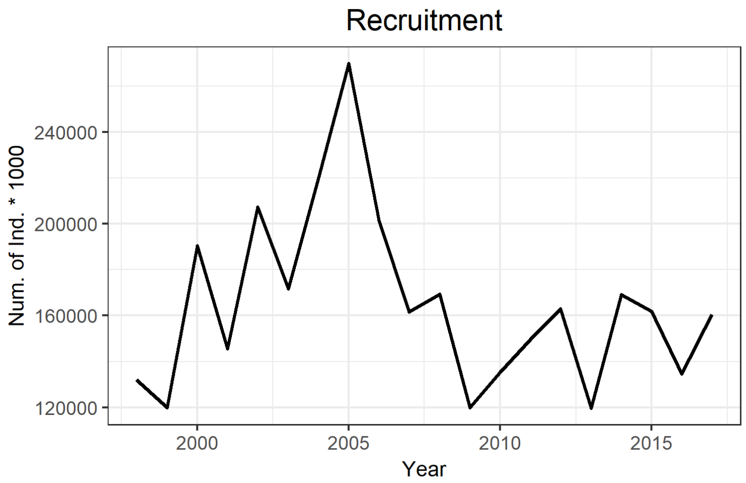


Figure 6.1.3.2. 10 Hake in GSAs 17 and 18. Recruitment by year estimated by the SS3 model.

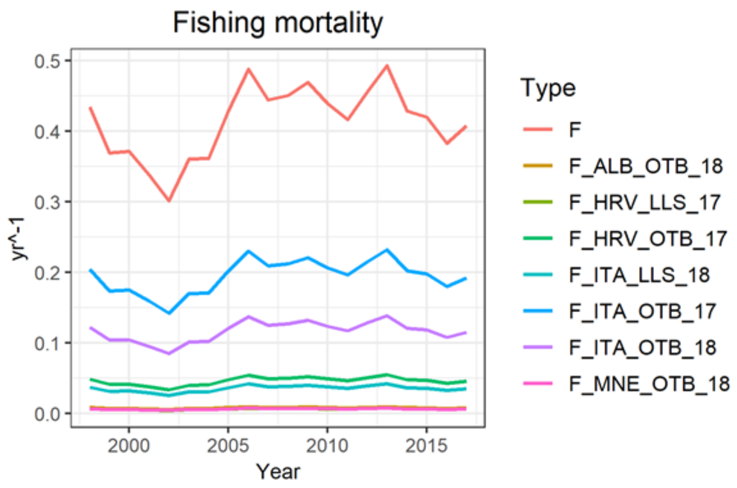


Figure 6.1.3.2. 11 Hake in GSAs 17 and 18. Total fishing mortality (red line), and divided by fleet, by year estimated by the SS3 model.

Retrospectives

Figures 6.1.3.1.12, 6.1.3.1.13 and 6.1.3.1.14 show the retrospectives obtained by running the SS3 model. The model seems stable since year minus two; removing the third year this stability is not showed any more suggesting that the model needs a more detailed investigation.

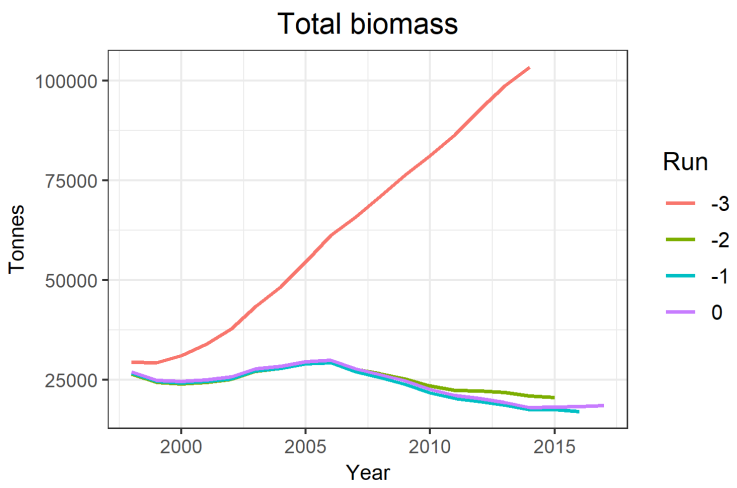


Figure 6.1.3.2. 12 Hake in GSAs 17 and 18. Retrospectives – Total biomass from SS3

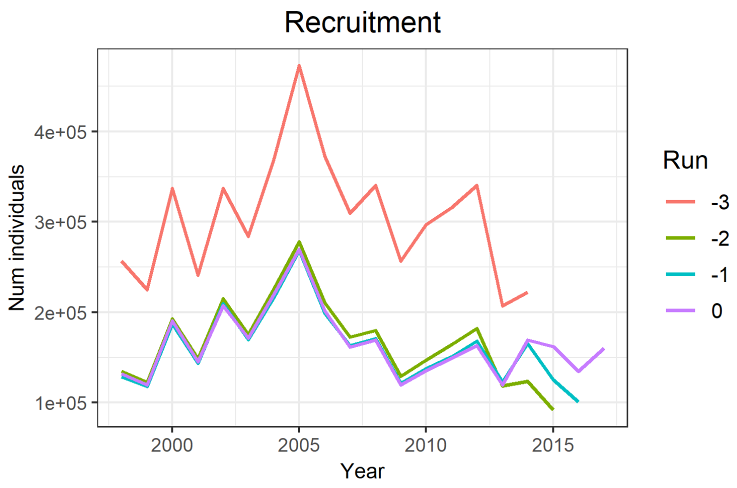


Figure 6.1.3.2. 13 Hake in GSAs 17 and 18. Retrospectives – Recruitment from SS3

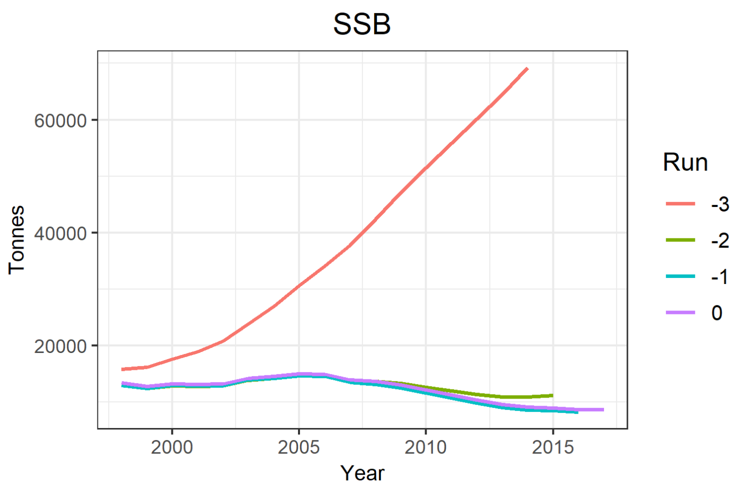


Figure 6.1.3.2. 14 Hake in GSAs 17 and 18. Retrospectives – Spawning stock biomass from SS3

6.1.3.3 CONCLUSIONS TO THE ASSESSMENT:

The two models a4a and SS3 gave similar results in terms of stock status, F/Fmsy total biomass and SSB in 2017 (Figure 6.1.3.3). The a4a model gives slightly higher historic F with a sharper decline in F over the last 4 years. The SS3 model has a higher starting biomass and SSB, but it's unclear which data is giving rise to these early values, as very few age classes from the start of the series have informative data. The earliest data is the MEDITS survey which detects mostly young individuals, and informs only ages 0 to 3 at the start of the SS3 model. Overall the a4a model appeared more stable based on the retrospective performance. The management advices are thus given considering the a4a model.

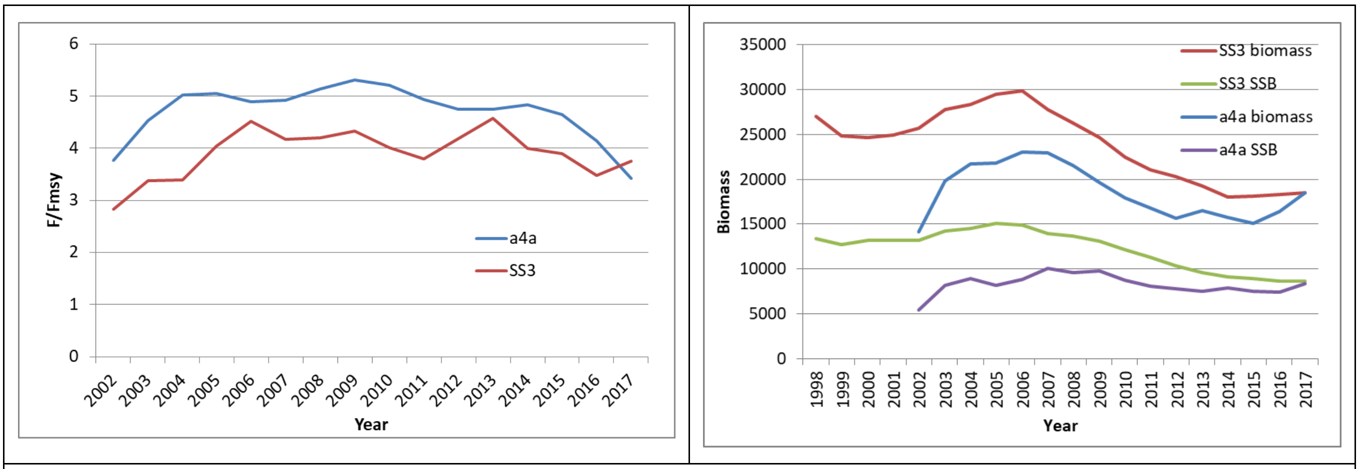


Figure 6.1.3.3 Comparison of F/Fmsy and biomass and SSB from the SS3 and a4a assessments.

6.1.4 Reference Points

Reference points were estimated both for a4a and SS3 using FLBRP package.

Considering the results obtained by a4a, estimated F0.1 resulted equal at 0.18. Given that the F estimated by the a4a model for 2017 is 0.60; the stock is being overexploited.

This stock results being in overexploitation also considering the SS3 model. In this case F.01 is estimated equal at 0.13, whereas the fishing mortality is 0.45 for 2017.

6.1.5 Short term Forecast and Catch Options

6.1.5.1 a4a (assessment for all)

A deterministic short term prediction for the period 2018 to 2020 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

The input parameters for the deterministic short-term predictions for the period 2016 to 2018 were the same used for the a4a stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} terminal from the a4a assessment was used due to a clear decreasing trend in F in the whole time series.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the whole time series (288663 thousand individuals).

Table 6.1.5.1. 1 Hake in GSAs 17 and 18. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2017	Catch 2018	Catch 2019	Catch 2020	SSB 2019	SSB 2020	Change SSB 2018-2020 (%)	Change Catch 2017-2019 (%)
Zero catch	0.0	0.00	5474.5	6712.5	0.0	0.0	12625.5	24412.4	126.7	-100.0
High long term yield ($F_{0.1}$)	0.3	0.18	5474.5	6712.5	2693.6	3866.7	12625.5	20480.1	90.2	-50.8
F_{upper}	0.4	0.26	5474.5	6712.5	3625.5	4908.5	12625.5	19137.5	77.7	-33.8
F_{lower}	0.2	0.12	5474.5	6712.5	1873.7	2825.6	12625.5	21669.3	101.2	-65.8
Status quo	1.0	0.60	5474.5	6712.5	7288.5	7594.6	12625.5	13974.1	29.7	33.1

Different Scenarios	0.1	0.06	5474.5	6712.5	930.9	1482.0	12625.5	23045.4	114.0	-83.0
	0.2	0.12	5474.5	6712.5	1809.1	2738.5	12625.5	21763.4	102.1	-67.0
	0.3	0.18	5474.5	6712.5	2637.9	3799.6	12625.5	20560.7	90.9	-51.8
	0.4	0.24	5474.5	6712.5	3420.3	4691.9	12625.5	19432.3	80.4	-37.5
	0.5	0.30	5474.5	6712.5	4159.2	5438.2	12625.5	18373.4	70.6	-24.0
	0.6	0.36	5474.5	6712.5	4857.2	6058.5	12625.5	17379.5	61.4	-11.3
	0.7	0.42	5474.5	6712.5	5516.9	6570.1	12625.5	16446.3	52.7	0.8
	0.8	0.48	5474.5	6712.5	6140.6	6988.2	12625.5	15570.1	44.6	12.2
	0.9	0.54	5474.5	6712.5	6730.4	7325.9	12625.5	14747.2	36.9	22.9
	1.1	0.66	5474.5	6712.5	7816.7	7804.1	12625.5	13247.8	23.0	42.8
	1.2	0.72	5474.5	6712.5	8316.8	7963.0	12625.5	12565.1	16.7	51.9
	1.3	0.78	5474.5	6712.5	8790.6	8078.9	12625.5	11923.3	10.7	60.6
	1.4	0.84	5474.5	6712.5	9239.5	8158.1	12625.5	11319.9	5.1	68.8
	1.5	0.90	5474.5	6712.5	9665.1	8206.2	12625.5	10752.3	-0.2	76.5
	1.6	0.96	5474.5	6712.5	10068.8	8228.1	12625.5	10218.4	-5.1	83.9
	1.7	1.02	5474.5	6712.5	10451.8	8228.0	12625.5	9716.0	-9.8	90.9
	1.8	1.08	5474.5	6712.5	10815.4	8209.4	12625.5	9243.2	-14.2	97.6
	1.9	1.14	5474.5	6712.5	11160.7	8175.6	12625.5	8798.0	-18.3	103.9
	2.0	1.20	5474.5	6712.5	11488.7	8129.0	12625.5	8378.7	-22.2	109.9

6.1.5.2 Stock synthesis

Short term prediction for the period 2018 to 2020 was run also starting from the SS3 and using the FLR libraries and scripts.

The input parameters for the deterministic short-term predictions for the period 2016 to 2018 were the same used for the SS3 stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age, recruitment and F_{bar}.

Table 6.1.5.2. 2 Hake in GSAs 17 and 18. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2017	Catch 2018	Catch 2019	Catch 2020	SSB 2019	SSB 2020	Change SSB 2018-2020 (%)	Change Catch 2017-2020 (%)
Zero catch	0	0	4237.419	7081.323	0	0	22173.44	30038.29	33.76442	-100
F0.1	0.3	0.130006	4237.419	7081.323	2336.474	2982.203	22173.44	27432.06	22.15852	-44.8609
F_{upper}	0.4	0.183232	4237.419	7081.323	3226.059	3944.309	22173.44	26444.11	17.75906	-23.86736
F_{lower}	0.2	0.088798	4237.419	7081.323	1621.767	2140.9	22173.44	28227.58	25.70108	-61.72748
Status quo	1	0.443956	4237.419	7081.323	7093.01	7082.948	22173.44	22181.54	-1.222706	67.38989
	0.1	0.044396	4237.419	7081.323	825.1377	1129.974	22173.44	29116.08	29.6577	-80.52735
	0.5	0.221978	4237.419	7081.323	3850.799	4564.677	22173.44	25751.83	14.67624	-9.12395
	0.6	0.266373	4237.419	7081.323	4543.97	5200.646	22173.44	24985.27	11.26265	7.234394
	0.7	0.310769	4237.419	7081.323	5213.865	5763.898	22173.44	24246.06	7.970865	23.04344

	0.8	0.355164	4237.419	7081.323	5861.417	6261.306	22173.44	23533.08	4.795871	38.32518
	0.9	0.39956	4237.419	7081.323	6487.515	6699.104	22173.44	22845.25	1.732873	53.10064
	1.1	0.488351	4237.419	7081.323	7678.717	7417.971	22173.44	21540.98	-4.075236	81.21213
	1.2	0.532747	4237.419	7081.323	8245.411	7708.829	22173.44	20922.61	-6.828892	94.58571
	1.3	0.577142	4237.419	7081.323	8793.836	7959.747	22173.44	20325.56	-9.48766	107.5282
	1.4	0.621538	4237.419	7081.323	9324.704	8174.558	22173.44	19748.95	-12.05535	120.0562
	1.5	0.665933	4237.419	7081.323	9838.692	8356.742	22173.44	19191.98	-14.5356	132.186
	1.6	0.710329	4237.419	7081.323	10336.45	8509.456	22173.44	18653.87	-16.93189	143.9327
	1.7	0.754724	4237.419	7081.323	10818.6	8635.564	22173.44	18133.86	-19.24755	155.3112
	1.8	0.79912	4237.419	7081.323	11285.74	8737.668	22173.44	17631.25	-21.48575	166.3353
	1.9	0.843516	4237.419	7081.323	11738.44	8818.126	22173.44	17145.35	-23.64953	177.0185
	2	0.887911	4237.419	7081.323	12177.23	8879.081	22173.44	16675.51	-25.74179	187.3738

6.1.6 DIAGNOSTICS FOR THE HAKE ASSESSMENT IN SS3

The integrated stock assessment software SS3 was applied to develop a potential assessment for the stock of hake in GSA 17 and 18. The assessment covers the years 1998 to 2017. The model developed in SS3 was disaggregated by sex, so as to account for the different growth of males and females. Sex-specific M-at-age patterns were assumed. Commercial fishing activity was split into 7 fleets. Each of the commercial fleets and the survey were assumed to have constant length-based selectivity over time; SS3 then internally derives the implied age-based selectivity from the length-based selectivity and growth parameters. No age composition data were included in the assessment. Length composition data, by sex and year, were available for 6 of the 7 fishing fleets and for the survey, although they were largely missing for the first decade of the assessment.

Setting up the SS3 stock assessment in a satisfactory manner proved very challenging. There are likely a number of reasons for this: the assessment time series is relatively short and there are no strong signals in the available fishery or survey data to drive assessment results in a clear way. No reliable age composition data are available for the assessment and there are strong uncertainties about growth. An important difficulty is that the Linfinity growth parameter values considered to be more realistic from a biological perspective (111 cm for females and 73 cm for males) are substantially larger than suggested by the length composition data. If these Linfinity values are indeed realistic, possible conclusions (given that such lengths are not observed in the data) are that the stock is heavily depleted, or that the natural mortality pattern is substantially different from that currently assumed, or that the fishery selectivity is even more dome-shaped than the domed doublé normal selectivities used in the above model, or a combination of these possibilities. If the growth parameters are estimated within the stock assessment, the estimated Linfinity values are considerably lower than the biologically realistic ones indicated above (the estimates being around 72 cm for females and 43 cm for males). These issues open a wide range of possibilities for developing an appropriate assessment, with none of them being clearly satisfactory and with no obvious way to clearly discern between them.

Two main SS3 configuration options were reached by the end of the assessment meeting: in one of them, the growth parameters were estimated and the selection patterns by length of the fleets were assumed to be the same for both sexes; in the other configuration, the growth parameters were treated as fixed inputs whereas the selection patterns of some of the fleets were allowed to differ by sex.

In SS3, the length-based selection of each fleet is internally normalised to have a maximum value of 1 over all lengths. As Fleet 5 (Italian LLS in GSA 18) is the fleet catching the larger hake, the intention was to impose an asymptotic or near-asymptotic selection pattern for the female hake catches of this fleet. This was done by constraining the sixth parameter of the double-Normal selectivity assumed for this fleet to lie in the interval 0.8 – 1. It was, however, realised after the meeting that this parameter is expressed in logit scale in SS3 and that the assumed interval actually corresponded to a selection in between exp(0.8)/(1+exp(0.8)) and exp(1)/(1+exp(1)), i.e. from 0.69 to 0.73 instead of the intended 0.8 – 1. A preliminary run conducted after the meeting with the corrected interval, including a retrospective analysis, suggests that the correction improves the stability of the assessment, but issues still remain to be clarified and/or improved for this assessment and they should be examined for the upcoming benchmark.

The fact that setting a reasonable starting "base case" run was found to be very difficult limited the time the meeting could spend on carefully exploring a full suite of relevant diagnostics. The very useful r4ss R package was applied during the meeting to display stock assessment results, including diagnostics such as plots showing the model fit to the observed survey index and the length composition data.

In the process of further developing and validating an SS3 model for the upcoming benchmark, the following list of diagnostics (points 1 to 15 below) seems useful. This list is directly taken from the document entitled "Model diagnostics for Stock Synthesis 3: Examples from the 2012 assessment of cobia in the U.S. Gulf of Mexico", by Cass-Calay *et al.*, published by ICCAT in 2014 (document SCRS/2013/025, Collect. Vol. Sci. Pap. ICCAT, 70(5): 2069-2081 (2014)). Under each point in the list, comments pertinent to the hake assessment have been included in the paragraph starting with the string "Hake assessment".

1. Does the model run?
    a. No → use echo input to debug
    b. Yes → continue

Hake assessment: b applies for the hake assessments developed at the meeting.

2. Does the hessian converge?
    a. No → check warning file, check estimated parameters in report file
    b. Yes → continue

Hake assessment: b applies for the hake assessments developed at the meeting.

3. Are there any parameters on bounds?
    a. No → continue
    b. Yes → change starting values / change bounds / add priors / simplify parameterization → rerun

Hake assessment: Some parameters are still hitting bounds; this needs to be further examined.

4. Plot model output. Anything obviously wrong? Examples: productivity way too low, selectivity patterns that don't make sense, drastic decrease/increase in biomass in a single year, abnormal recruitment patterns (boom/bust).
    a. No → continue
    b. Yes → go through report file to diagnose (depends on problem)

Hake assessment: When estimating the growth parameters in the stock assessment, the estimated Linfinity values are substantially lower than those considered biologically realistic. When fixing the growth parameters at values considered to be biologically realistic, the estimated length-based selectivities for some fleets seem ilogical, e.g. some OTB fleets (mainly, but not exclusively, the Italian OTB fleet in GSA 18) are estimated to have higher selectivity at large lengths than LLS fleets; the OTB fleets for which this unexpected phenomenon occurs can change when years of data are removed in retrospective runs and this seems to be related with the lack of stability observed in retrospective results (see point 13 below). The issue is not well understood and needs to be further examined.

5. Examine parameter estimates. Plot parameter distributions along with starting values, bounds, and priors. Do parameters appear well estimated?
    a. No → check bounds, check priors, check phase of estimation
    b. Yes → continue

Hake assessment: Some parameters are still hitting bounds, as noted above (point 3). This needs to be further examined.

6. Look at trace plots of parameter estimates relative to phase of estimation? Do model parameters change considerably in the final phase?
    a. No → continue
    b. Yes → try alternative phases: for example, important scaling parameters like unfished recruitment and catchability might be estimated in the first phase, recruitment deviates estimated added in the second phase, and selectivity added in the final phase.

Hake assessment: Parameter values per iteration of the estimation algorithm are provided in the SS3 output file "ParmTrace.sso" and trace plots can be easily produced from the values in this file. A simple piece of R code to do this plot was produced during the meeting. Trace plots were produced for the hake runs in the meeting; at first sight, the trace plots did not indicate any obvious problem but more careful inspection than was possible during the meeting would be appropriate.

7. Look at mean and standard deviation of estimated parameters. Is CV of estimated parameters less than 1?
    a. No → is there data to inform parameter?
        i. No → change bounds/add informative prior/fix parameter
        ii. Yes → check correlation matrix
    b. Yes → continue

Hake assessment: Parameter estimates and corresponding standard deviations are reported in the SS3 "Report.sso" file. Stock assessment results can be read into an R session using the "SS_output" function of the r4ss package; approximate CVs can then be calculated as the standard deviation divided by the parameter estimate. A simple piece of R code was produced during the meeting to identify parameter estimates whose CVs are above a selected threshold. As already noted, there was little time during the meeting to consider outputs carefully and, therefore, more careful inspection of the CVs for the hake assessment would be appropriate.

8. Are any of the parameters highly correlated?
    a. No → continue
    b. Yes → why? Does one of the parameters require an informative prior?

Hake assessment: Correlations between parameter estimates can be obtained from the "covar.sso" output file. A simple piece of R code was produced during the meeting to identify pairs of parameter estimates for which the magnitude of the correlation is above a selected threshold. Some of the high correlations observed in the hake assessment seem logical, as is the case e.g. for the high positive correlation observed between parameters P1 (length at which the selectivity first reaches its highest value) and P3 (width of the selectivity curve below P1) of the double-Normal selectivity function of some fleets. More careful inspection of the correlations for the hake assessment would be appropriate.

9. Plot model fits to data and diagnostics. Is model fitting data reasonably?
    a. No → diagnose the problem.
    b. Yes → continue

Hake assessment: Fits seem reasonable for the hake assessments developed at the meeting. The assessment with fixed growth parameters strongly overestimated the amount of male hake observed in the LLS fleets; allowing for sex-specific selectivity in those fleets, including the possibility of males having overall lower selectivity than females, resulted in considerable improvement in the fit to these data.

10. Check for model stability to initial starting parameters using Jitter analysis. Does model converge to a "global" solution?
    a. No → identify why.
        i. look at which likelihood components are changing
        ii. Evaluate the phases of estimation
        iii. Plot distribution of estimated parameters over all model runs
    b. Yes → continue (try again with larger deviation from starting values)

Hake assessment: From the explanation in the SS3.30 manual, it is understood that the jittered starting parameter values are calculated internally in SS3 as follows:

First, a normal distribution is calculated such that pr(Pmin) = 0.01% and pr(Pmax) = 99.9%. Then, a new cumulative normal probability value, J, is randomly drawn from the range going from pr(Pcurrent)-jitter_fraction to pr(Pcurrent)+jitter_fraction, with the constraint that it cannot be <0.1% or > 99.9% of the distribution. Finally, a new starting parameter value, Pjittered, is calculated such that pr(Pjittered) = J.

The value of "jitter_fraction" must be specified in the "starter.ss" file of SS3. An R function was produced after the meeting to automatically update the "jitter_fraction" value in the starter file and to conduct multiple assessments with jittered starting parameter values and to compare the results from the different assessments. This function was prepared after the meeting and still requires additional testing to ensure it works correctly. There is also an "SS_RunJitter" function in the r4ss package, but there has been no time to explore it during or after the meeting.

11. Profile leading model parameters such as stock-recruitment parameters (steepness/R0) or natural mortality. Was the profile smooth?
    a. No → Plot estimated parameters as a function of profiled leading parameter

i. Do any of the parameters hit bounds across the runs? Do any of the parameters bounce between alternative solutions? Do some parameters show similar patterns?

1. Yes → may not have enough data to inform all estimated parameters: add informative priors/reduce the number of estimated parameters.

b. Yes → Does profile show leading parameter is well estimated? Do the different data components show similar signals?
   i. No → parameter may require informative prior or need to be fixed
   ii. Yes → profile at finer scale 1. Does profile remain smooth?

a. Yes → continue

Hake assessment: There was no time to explore this during the meeting. However, an R script was created after the meeting to facilitate this examination in future work. The script appears to work correctly, but additional testing is still required to ensure this is indeed the case. As a preliminary testing exercise, the script was run to conduct a profile analysis on R0 for one of the SS3 hake runs. The resulting likelihood profile was smooth, and suggested that the likelihood component corresponding to length composition data favours larger values of R0 than those corresponding to the survey index and equilibrium catch.

12. Evaluate model sensitivity to key model assumptions, data weighting choices, and alternative data inputs. Was model highly sensitive to any key model assumptions or certain data sources?

   a. No → continue
   b. Yes → Is model specified correctly? Are assumptions appropriate? Is model overparameterized? Should data be re-weighted?

Hake assessment: There was very limited time to explore this during the meeting and further analysis to understand the impact of alternative weighting schemes for the length composition data would be relevant. The so-called "Francis weighting" is now commonly used and the r4ss package provides guidance to help set weights in accordance with such a weighting scheme. An alternative could be to use the Dirichlet-Multinomial option available in SS 3.30 and let the SS software estimate the sample size adjustment of the length composition data. The Dirichlet-Multinomial option was attempted quickly before the meeting, using an earlier SS configuration of the hake assessment, but convergence difficulties were encountered. Further exploration of potential data weighting schemes and their impacts on the stock assessment would be relevant.

13. Evaluate model sensitivity to the most recent years of data using a retrospective analysis. Did the retrospective analysis reveal any inconsistencies in the data?
   a. No → continue
   b. Yes → identify source of the retrospective pattern

Hake assessment: Retrospective runs were conducted at the end of the meeting and suggested that the final model configurations lacked stability in retrospective runs. The issue requires further investigation. An R script to conduct retrospective analyses in a fairly automatic way is being developed to facilitate this task.

14. Evaluate model uncertainty using bootstrap approach. Plot distribution of parameter estimates and derived quantities from bootstrapped runs. Compare MLE of parameter estimates to mean of bootstrap results. Are parameters or derived quantities well estimated when data is resampled?
   a. No → do distributions show multi-modality or high proportion of bounding?
      i. Yes → may not have enough data to inform all estimated parameters: add informative priors/reduce the number of estimated parameters.

b. Yes → continue

Hake assessment: This has not been explored so far.

15. Evaluate model convergence using MCMC approach. Use standard approaches to evaluating MCMC results: look at trace plots/plot posterior distributions/compare MLE to mean of posterior distribution. Does MCMC converge on a single solution? Are MLEs of parameters/derived quantities similar to mean of posterior distributions?
    a. No →
    b. Yes → continue

Hake assessment: This has not been explored so far.

In addition to the above, key SS3 developers (R. Methot and some of his close collaborators) provided helpful information on diagnostics in SS3 and, generally, in integrated assessments. Some initial thoughts they provided for SS3 assessments in general (i.e. not specific to the hake assessment) were:

1. Conduct profile on R0 and examine response of logL for each data type to disclose conflicts.

2. Tune the bias adjustment for recruitment deviations so it is in balance with the degree to which var(recdevs) approaches sigma_r^2.

3. Look for patterns in residuals and consider whether time-varying q or selectivity is justified.

3. Use information on goodness of fit to composition data to tune the sample sizes. Francis weighting has become the norm. Or use the Dirichlet-Multinomial option in SS 3.30 and let SS estimate the sample size adjustment.

4. Use the extra_sd option for surveys and CPUE to adjust their residual variance.

5. Do not use asymptotic selectivity unless it can really be justified, as it has a big impact on model results.

Their team is currently preparing a document on good practices for developing SS3 assessments. Their work is in progress and will be further consulted in the build-up to the benchmark assessment for the hake stock.

6.2 Red mullet in GSA 17 and 18

6.2.1 Stock indentity and biology

STECF 18-16, after analysing the results of the STOCKMED project, concluded that the region represented by the GSAs 17 and 18, corresponding to the Adriatic Sea Sea, is considered inhabited by a unique stock unit. During the GFCM Working Group on Demersal Species (WGSAD) in 2017, a first attempt of joint assessment with Stock Synthesis model was presented. This attempt was made on the basis of the analysis of the survey indices, showing a very similar increasing trend in both areas in the recent years, and considering that the Western side of both GSAs was characterized by a decrease in effort from 2004 to 2016.

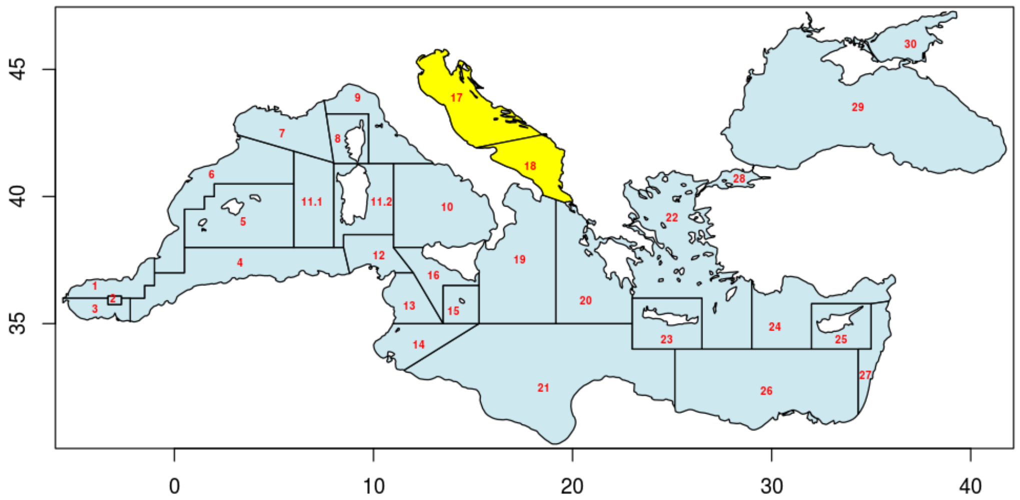


Figure 6.2.1.1 Geographical location of GSAs 17 and 18.

Growth

The von Bertalanffy parameters by sex from the official Data call for GSA 18 were used in the assessment and reported in Table 6.2.1.1.

The parameters have been estimated in GSA 18 for sex combined, using the mean lengths from Age-Length key from commercial sampling (discard and landing) and MEDITS survey from 2011 to 2016. A constraint has been included in the VBF fitting to take into account the exceptional finding of 4 cm-sized metamorphosed individuals during MEDITS trawl survey.

Table 6.2.1.1 Red mullet in GSAs 17 and 18. von Bertalanffy growth parameters for red mullet used for GSAs 17 and 18.

GSA	Sex	L_{inf} (cm)	k	t_0
17-18	F	29.185	0.247	-0.768
17-18	M	22.725	0.328	-0.816

Maturity

The vector of proportion of mature individuals by age has been derived associating the proportion of matures of the length from DCF derived by von Bertalanffy calculated in the middle of age class. The assessment was carried out using the maturity at age estimated in GSA 18 from DCF data.

Table 6.2.1.2 Red mullet in GSAs 17 and 18. Maturity at age.

Age	Prop. mature
0	0.0
1	0.7
2	1.0
3	1.0
4+	1.0

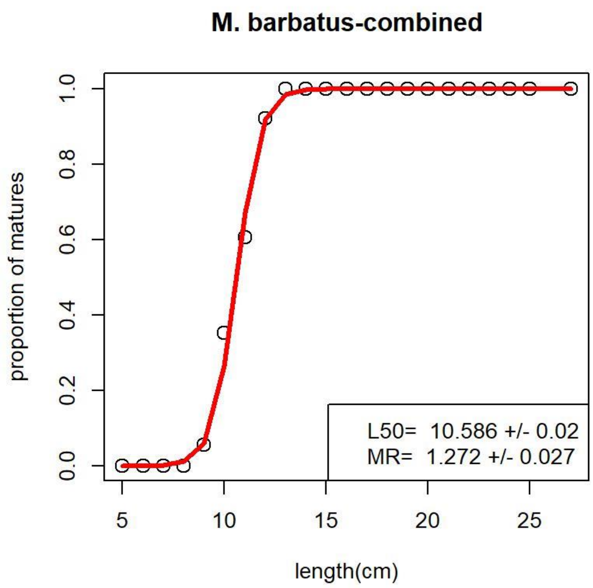


Figure 6.2.1.2 Red mullet in GSAs 17 and 18. Maturity at length (sex combined) from DCF 2016.

Natural mortality

The natural mortality vector has been estimated as a weighted average by sex using the Chen and Watanabe method to be consistent with the benchmark assessments of GFCM WGSAD 2016 (where a sensitivity analysis on natural mortality vectors was carried out).

Table 6.2.1.3 Red mullet in GSAs 17 and 18. Natural mortality at age (Chen and Watanabe model).

Age	M
0	1.41
1	0.71
2	0.52
3	0.42
4+	0.37

6.2.2 Data

6.2.2.1 Catch (landings and discards)

Red mullet landings in GSAs come predominantly from OTB; a small amount is reported for small-scale fishing gears (gillnet and trammel net).

Table 6.2.2.1.1 Red mullet in GSAs 17 and 18. Landings in GSA 17 by fishing gear and country over 2006-2017 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; PTM=mid-water pair trawl; TBB=beam trawl; OTB=otter bottom trawl).

year	GSA 17 ITA GNS	GSA 17 ITA OTB	GSA 17 ITA PTM	GSA 17 ITA TBB	GSA 17 HVR OTB	GSA 17 SLV OTB	GSA 17 MLT OTB	GSA 17 Total
2006		3100.6				1.9		3102.5
2007		3298.5				6.4		3304.9
2008		3158.3				2.0		3160.3
2009		2433.4				2.7		2436.1
2010		1796.2				1.3		1797.4
2011	31.2	1822.9		36.2		6.1		1896.3
2012	17.6	1463.6		43.2		3.6		1527.9
2013		1946.1	2.4	31.0	1084.3	2.4		3066.1
2014	7.6	2323.9	2.5	63.6	1151.7	3.3		3552.7
2015	15.6	2142.8		60.9	1128.1	3.4	0.5	3351.3
2016	4.5	2036.8			953.4	2.3		2997.0
2017	9.0	2659.0		4.0	985.5	3.4		3660.8

Table 6.2.2.1.2 Red mullet in GSAs 17 and 18. Landings in GSA 18 by fishing gear and country over 2002-2017 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; OTB=otter bottom trawl).

year	GSA 18 ITA -1	GSA 18 ITA GNS	GSA 18 ITA GTR	GSA 18 ITA OTB	GSA 18 Total
2002	1707.3	89.6		3114.2	4911.1
2003	307.8	312.0		1749.8	2369.5
2004		82.5		1981.1	2063.6
2005		99.3		1350.0	1449.5
2006	1.2	123.5	6.3	1803.5	1934.4
2007	0.1	119.8	2.7	1679.6	1802.2
2008		41.9	4.7	914.2	960.8
2009		75.9	0.8	954.6	1031.3
2010		44.0	1.4	600.8	646.2
2011		37.1	0.4	494.2	531.7
2012		7.1	0.6	2088.6	2096.3
2013		47.0		1202.8	1249.8
2014		4.5	18.1	1249.6	1272.2
2015		15.3		1572.1	1587.4
2016		50.5		1397.6	1448.0
2017		0.2	66.3	553.0	619.5

Table 6.2.2.1.3 Red mullet in GSAs 17 and 18. Discards by GSA, fishing gear and country as reported in the DCF (tonnes; GNS=gillnet;TBB=beam trawl; OTB=otter bottom trawl). Note the high amount OTB discards in GSA 17 in relation to landings.

year	GSA 17 ITA OTB	GSA 17 ITA TBB	GSA 17 SLV OTB	GSA 17 HRV OTB	GSA 17 Total	GSA 18 ITA GNS	GSA 18 ITA OTB	GSA 18 Total
2005			0.1					
2006			0.0					
2007			0.2					
2008			0.0					
2009			0.0				14.7	14.7
2010	183.0		0.0		183.0		35.0	35.0
2011	795.9	7.4	0.1		803.5	5.4	13.9	19.3
2012	324.6		0.1		324.6		434.1	434.1
2013	291.1		0.0	3.1	294.2	1.4	18.1	19.4
2014	446.4		0.1	2.2	448.7		119.6	119.6
2015	909.8		0.1	0.9	910.8		89.4	89.4
2016	499.2		0.0	1.1	500.3		87.4	87.4
2017	1069.0	3.0	0.1	3.6	1075.7		13.2	13.2

For Montenegro and Albania, the annual proportions in the length classes of GSA 17 and 18 were applied to the landing times series available from the same report (2007-2016). LFDs from Croatia were available from 2013; for landings from Croatia of previous years (2009-2012) the annual proportions in the length classes of GSA 17 and 18 were applied. No discard data were available for Albania and Montenegro.

Table 6.2.2.1.4 Red mullet in GSAs 17 and 18. Total catch (tonnes). Albania and Montenegro data were obtained from GFCM WGSAD 2017.

	SA17 OTB_ITA	SA17 OTB_HRV	SA18 OTB_ALB	OTB_MTN	NET_MTN	SA18 OTB_ITA	SA18 NET_ITA	TOTAL
2006	3101.0					1803.0	130.0	5034.0
2007	3299.0		171.0			1680.0	123.0	5273.0
2008	3158.0	767.0	149.0	38.0	3.7	914.0	47.0	5076.7
2009	2433.0	818.0	154.0	36.0	3.6	969.7	77.0	4491.3
2010	1979.0	763.0	90.0	35.0	3.4	636.0	45.0	3551.4
2011	2694.0	1086.0	110.0	32.0	3.2	507.9	43.4	4476.5
2012	1849.0	1248.0	375.0	35.0	3.5	2523.1	8.0	6041.6
2013	2271.0	1086.0	373.0	32.0	3.1	1221.1	48.4	5034.6
2014	2844.0	1158.0	317.0	41.0	4.0	1369.6	23.0	5756.6
2015	3129.0	1127.0	388.0	36.0	3.6	1661.4	15.0	6360.0
2016	2541.0	951.0	396.0	36.0	3.6	1485.4	50.0	5463.0
2017	3744.0	990.0	392.0	36.0	3.6	566.0	67.0	5798.6

Red mullet LFDs of landings and discards by GSA and fishing gear as reported in the DCF are presented in Figures 6.2.2.1.1-6.2.2.1.3.

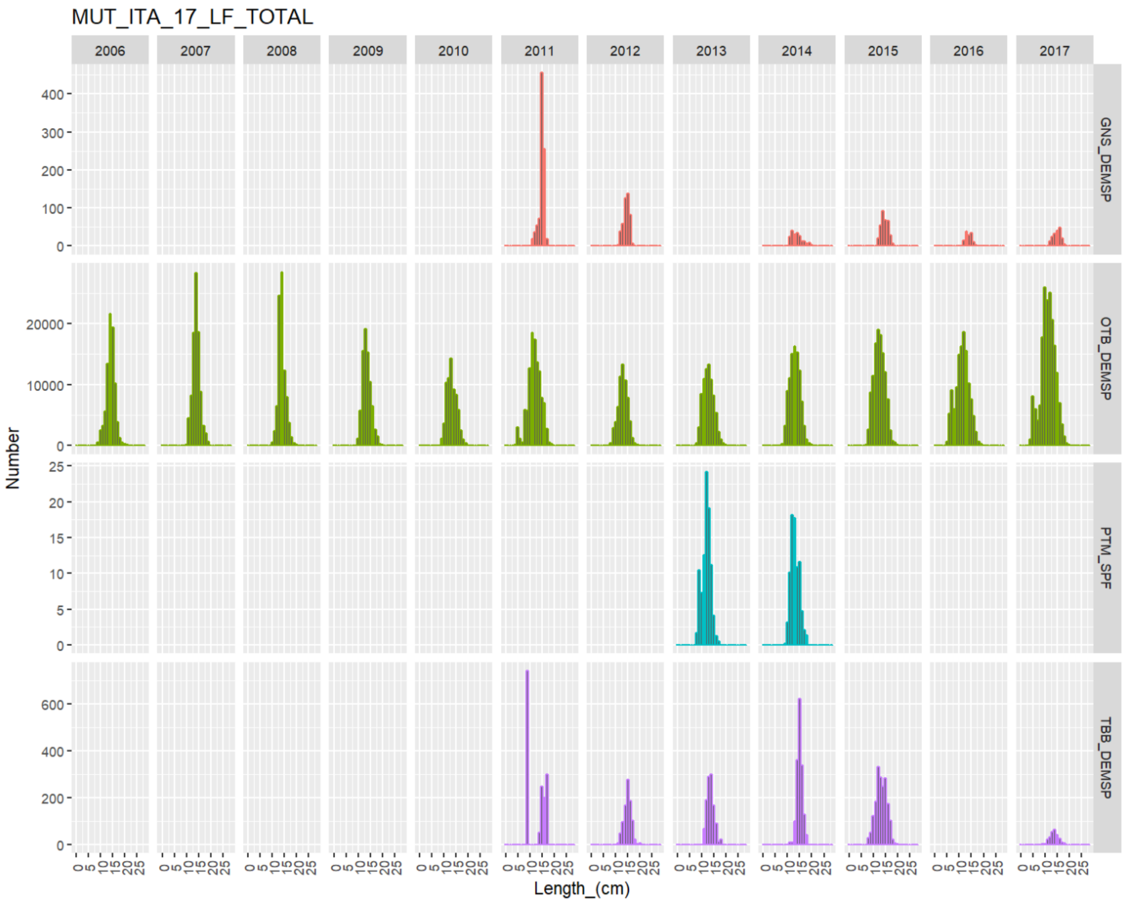


Figure 6.2.2.1.1 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Italy.

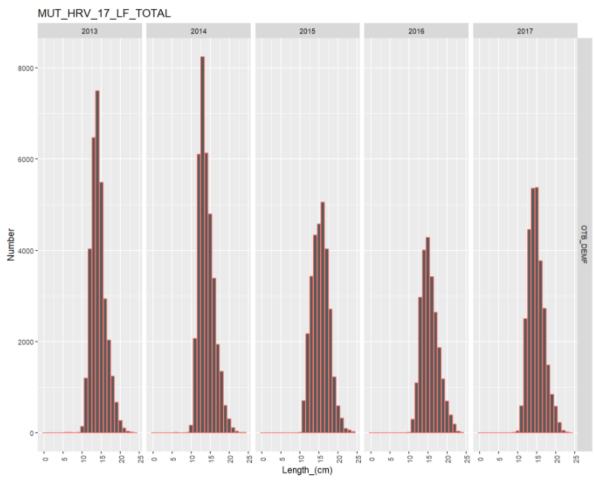


Figure 6.2.2.1.2 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Croatia.

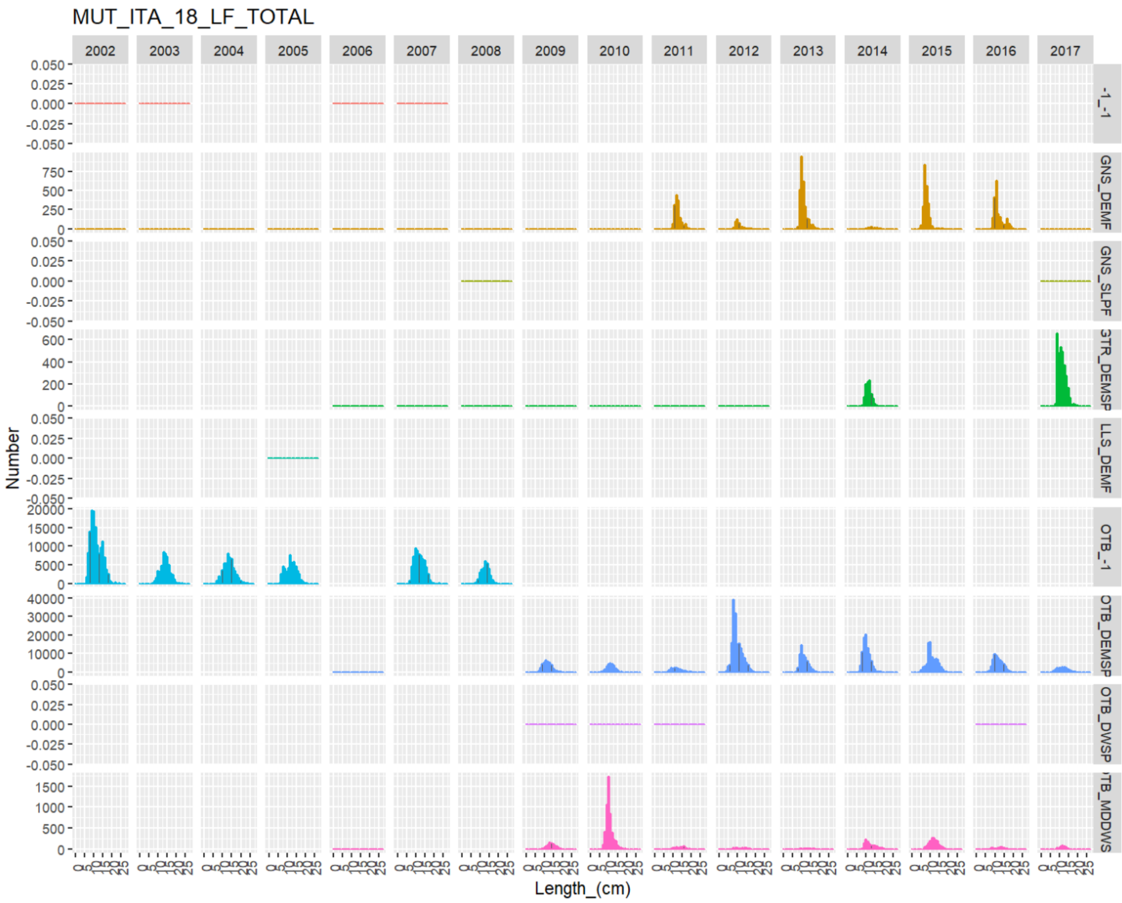


Figure 6.2.2.1.3 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 18, Italy.

6.2.2.2 EFFORT

The effort data are available for GSA17 (Italy and Croatia) and 18 (Italy). The fishing effort for the gears targeting red mullet in terms of GT*fishing days and fishing days is reported in Tables 6.2.2.2.1 and 6.2.2.2.2.

Table 6.2.2.2.1 Red mullet in GSA 17 and 18. Fishing effort (GT*days at sea)/fishing gear/year in GSA 17-18 of the gears targeting red mullet in the same area.

Country/GSA	Year	GNS	GTR	OTB	TOTAL
HRV_17	2012	161601	126635	1289335	1577571
HRV_17	2013	146238	130299	1373511	1650048
HRV_17	2014	150427	116713	1381570	1648710
HRV_17	2015	144366	128027	1346257	1618650
HRV_17	2016	145114	109194	1231785	1486093
ITA_17	2006	216424	79544	4079669	4375637
ITA_17	2007	156782	101669	4056776	4315227
ITA_17	2008	135113	56788	4082465	4274366
ITA_17	2009	173403	65074	3830475	4068952
ITA_17	2010	190223	66358	3837446	4094027
ITA_17	2011	236375	79984	3482614	3798973
ITA_17	2012	259488	78308	3130643	3468439
ITA_17	2013	167797	64034	2645415	2877246

ITA_17	2014	233376	45568	2836181	3115125
ITA_17	2015	139371	55459	2872228	3067058
ITA_17	2016	178800	59674	3014054	3252528
ITA_18	2006	117032	31528	2662179	2810739
ITA_18	2007	70224	45292	2294240	2409756
ITA_18	2008	51447	83968	2039422	2174837
ITA_18	2009	79662	80946	2386555	2547163
ITA_18	2010	57056	79765	2068044	2204865
ITA_18	2011	44943	79593	1900240	2024776
ITA_18	2012	38287	60542	1668749	1767578
ITA_18	2013	78862	8196	1994855	2081913
ITA_18	2014	21679	51077	1463644	1536400
ITA_18	2015	78693	12679	1355193	1446565
ITA_18	2016	88202	5609	1429243	1523054

Table 6.2.2.2.2 Red mullet in GSA 17 and 18. Fishing effort (Days at sea)/fishing gear/year in GSA 17-18 of the gear targeting red mullet in the same area.

Country/GSA	Year	GNS	GTR	OTB	TOTAL
HRV_17	2012	60504	34888	39128	134520
HRV_17	2013	56041	37239	39226	132506
HRV_17	2014	57411	34860	40553	132824
HRV_17	2015	56695	36132	39074	131901
HRV_17	2016	56630	32426	37201	126257
ITA_17	2006	323310	244244	434655	1002209
ITA_17	2007	224242	224242	382493	830977
ITA_17	2008	270057	197633	354510	822200
ITA_17	2009	526142	261673	345095	1132911
ITA_17	2010	424178	231216	329764	985157
ITA_17	2011	419686	344909	333303	1097898
ITA_17	2012	514255	227536	322785	1064577
ITA_17	2013	224894	245016	292130	762039
ITA_17	2014	258913	167612	259502	686027
ITA_17	2015	220612	140111	265839	626562
ITA_17	2016	266064	145210	258656	669930
ITA_18	2006	109714	80000	201679	391394
ITA_18	2007	71797	71797	176345	319940
ITA_18	2008	121136	81506	253577	456218
ITA_18	2009	124844	87533	316411	528788
ITA_18	2010	88940	88940	292887	470766
ITA_18	2011	87234	87234	222708	397177
ITA_18	2012	76470	76470	157792	310731
ITA_18	2013	82110	23036	143901	249047
ITA_18	2014	73021	73021	157301	303344
ITA_18	2015	63400	60311	154211	277922
ITA_18	2016	54072	47977	160570	262619

6.2.2.3 SURVEY DATA

MEDITS survey data are available from the official Data call for GSA 17 and for GSA 18 from 1994. All the Countries are covered by the survey data. For the present assessment the data from 2006 to 2017 were used.

The long duration and the shift in the survey time in some years (Italy) may be critical for species such as red mullet, with a short spawning period, in late spring, and recruitment in autumn. Thus, in the years when the survey ends in summer recruits will be absent or their presence very low, while when the survey ends in autumn recruits will be present in the catches (see Fig. 6.2.2.3.1).

All the surveys explored reveal a strong increase in the density and in the biomass indices (Figure 6.2.2.3.2) from 2011 onwards.

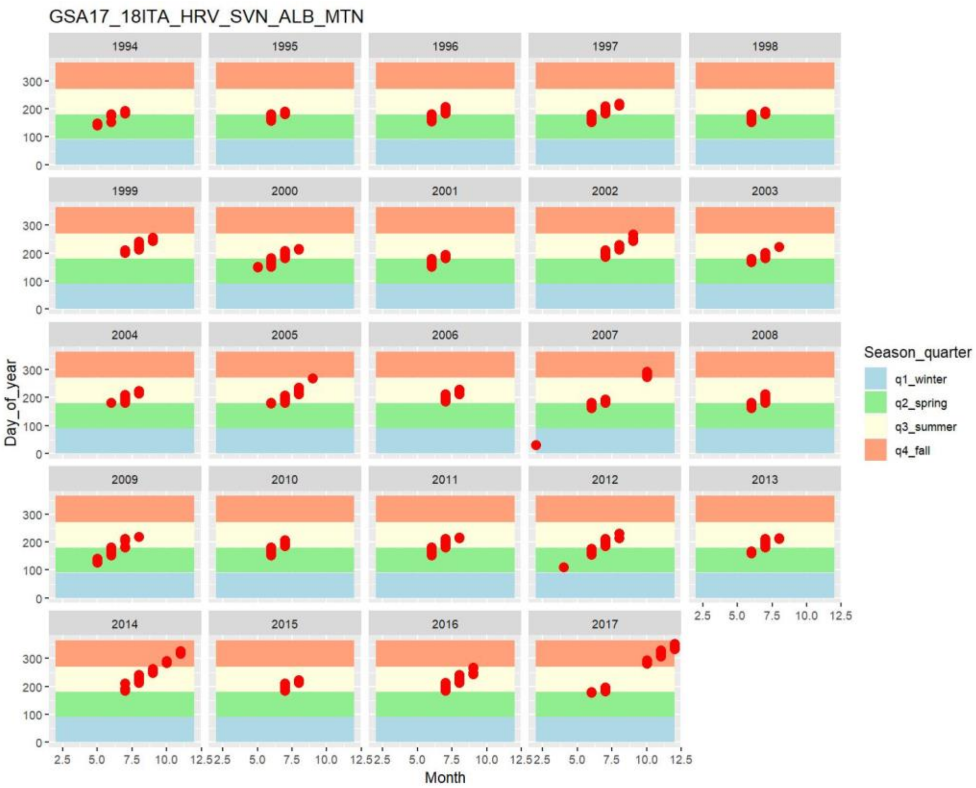


Figure 6.2.2.3.1 Red mullet in GSAs 17 and 18. MEDITS survey period over 1994-2017. Note that the duration of the MEDITS survey, depending on the year, extends over different quarters.

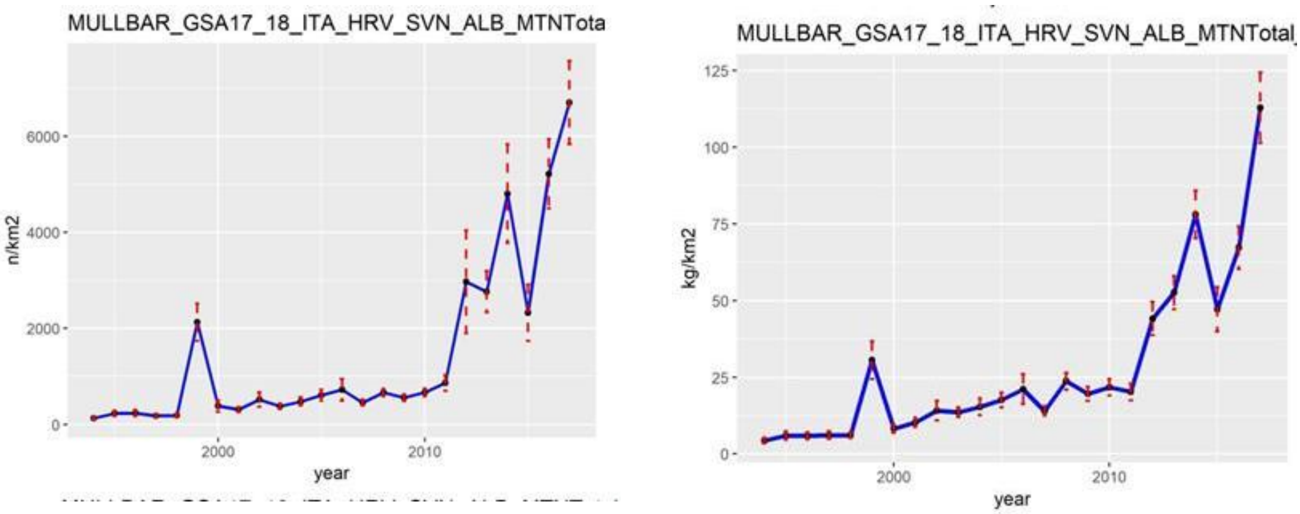


Figure 6.2.2.3.2 Red mullet in GSAs 17 and 18. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2017.

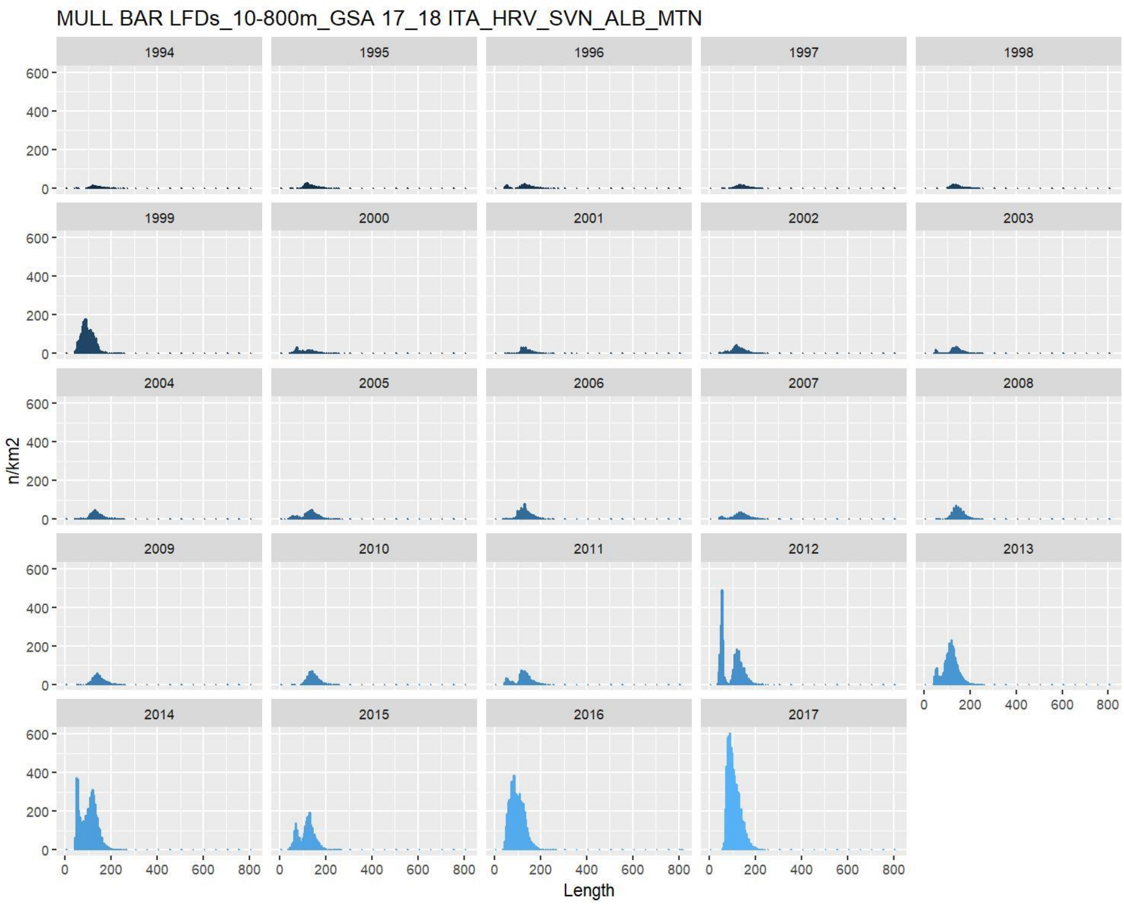


Figure 6.2.2.3.3 Red mullet in GSAs 17 and 18. MEDITS Length frequency distribution (TL mm; n/km^2).

6.2.3 Stock assessment

Methods: a4a (Assessment for all)

A4a is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by fleet. The method was developed within FLR framework.

Input data

The MEDITS indices by length were estimated treating the two GSAs combined as a unique area, starting from the TC files and re-stratifying the single hauls in the TA files.

Commercial catch, LFDs were available from 2002 only in GSA 18 (Italy); therefore, it was decided to use data from 2006 onwards, as LFDs are available in the two GSAs from most of the countries.

The length frequency distributions of all the fleets and the MEDITS LFDs on the whole area were age sliced by means of a deterministic slicing (l2a function available in FLR) using the von Bertalanffy parameters reported in the EU DCF database for GSA18 (reported in paragraph 6.2.1.1). The LW relationship parameters available on the DCF database were used to calculate the mean weight-at-age. Age slicing and the computation of mean weight-at-age were performed by sex, then age structures were pulled together, while the mean weight-at-age for sex combined was estimated as a weighted average of the mean weight-at-age by sex.

The catch-at-age matrices are reported in Table 6.2.3.1 (commercial) and 6.2.3.2 (survey). The overall catch in weight by year is reported in Table 6.2.3.3. The age structure of catch and survey is also shown in Figures 6.2.3.1 and 6.2.3.2.

The natural mortality vector and the maturity at age are the same reported in paragraph 6.2.1.1. The M and F before spawning were set equal to 0.5. In Table 6.2.3.4, the mean weights-at-age for the stock and for the catch are reported.

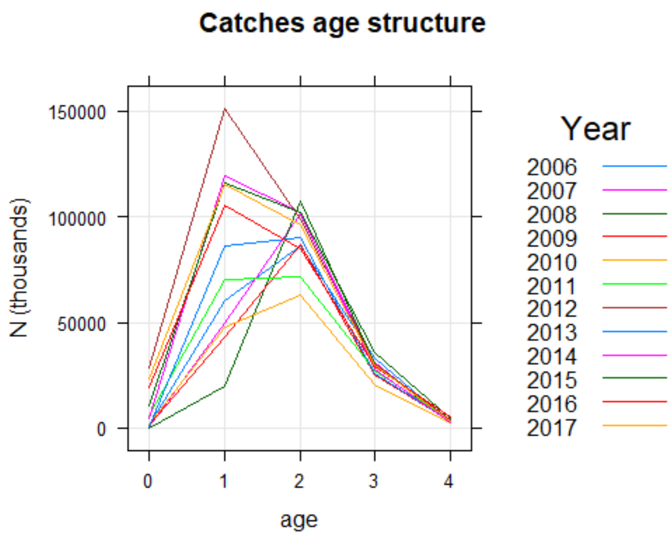


Figure 6.2.3.1 Red mullet in GSAs 17 and 18. Catch at age (landings+discards), all gears and GSAs combined.

Table 6.2.3.1 Red mullet in GSAs 17 and 18. Commercial catch in numbers at age used in the a4a assessment (thousands).

Year/Age	0	1	2	3	4+
2006	1054	60486	86284	33093	2749
2007	808	49414	101541	31337	2444
2008	45	19932	107572	30437	2789
2009	1143	42817	87199	25381	3245
2010	1703	48071	62838	20328	2522
2011	5779	70435	71646	27023	3688
2012	28732	151177	98598	30612	3961
2013	411	86459	90197	26008	2987
2014	4879	119347	102445	27779	2874
2015	10372	116230	102103	36029	4869
2016	18968	105241	85230	29244	4964
2017	23307	115277	96361	29854	3521

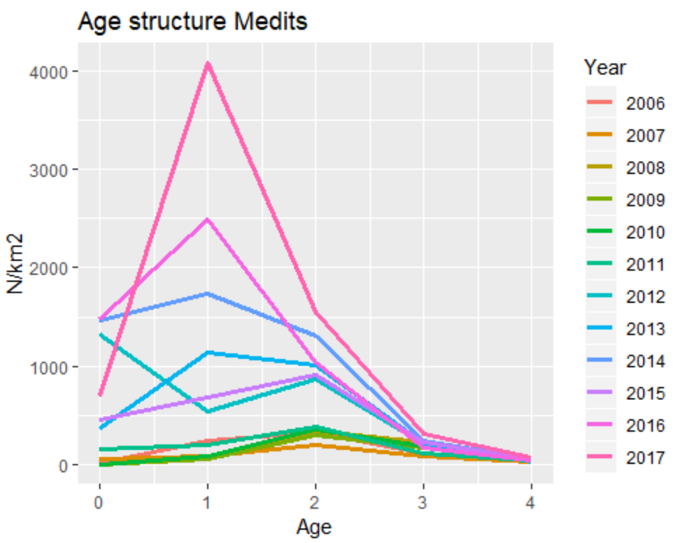


Figure 6.2.3.2 Red mullet in GSAs 17 and 18. Catch at age in the MEDITS survey (GSA17 and 18 combined).

Table 6.2.3.2 Red mullet in GSAs 17 and 18. MEDITS catch in numbers at age used in the a4a assessment (N/km^2).

Year/Age	0	1	2	3	4+
2006	8.2	236.1	325.9	113.0	38.3
2007	50.3	87.5	199.8	87.1	28.1
2008	1.5	57.2	331.8	219.6	52.6
2009	0.6	54.2	290.4	162.2	46.8
2010	0.3	84.5	355.5	184.4	41.2
2011	146.0	194.7	382.1	111.5	32.4
2012	1325.3	531.5	864.5	207.5	28.4
2013	371.8	1129.5	1010.7	208.9	41.0
2014	1463.7	1729.2	1311.2	244.3	52.4
2015	452.9	677.9	909.5	227.8	56.6
2016	1477.4	2489.8	1038.0	173.4	42.9
2017	695.3	4082.9	1548.5	306.8	66.1

Table 6.2.3.3 Red mullet in GSAs 17 and 18. Catch in weight by year (tons).

Year	Catch (tons)
2006	5034
2007	5272
2008	5077
2009	4491
2010	3552
2011	4476
2012	6041
2013	5034
2014	5756
2015	6361
2016	5462
2017	5798

Table 6.2.3.4 Red mullet in GSAs 17 and 18. Individual weight at age for the in the catch and stock (kg).

Year	0	1	2	3	4+
2006	0.004	0.012	0.029	0.048	0.075
2007	0.004	0.012	0.029	0.048	0.075
2008	0.004	0.014	0.029	0.049	0.078
2009	0.003	0.014	0.027	0.050	0.080
2010	0.003	0.013	0.027	0.049	0.081
2011	0.002	0.012	0.027	0.049	0.081
2012	0.003	0.010	0.027	0.049	0.079
2013	0.003	0.012	0.027	0.049	0.078
2014	0.003	0.012	0.027	0.049	0.079
2015	0.003	0.012	0.028	0.049	0.080
2016	0.003	0.012	0.027	0.049	0.082
2017	0.002	0.012	0.027	0.050	0.079

Different combinations of F, q and stock-recruitment sub-models were explored. The list of the sub-models is reported below:

F sub-model:

~ te(age, year, k = c(3,5)) + s(year, k = 4, by = as.numeric(age==0))

~s(age, k = 3) + s(year, k = 5,6,7)

~s(replace(age, age > 3, 3), k = 3) + s(year, k = 7)

~s(age, k = 3) + s(year, k = 5) + s(year, k = 5, by = as.numeric(age == 0))

~ s(replace(age,age>3,3),k = 3, by = breakpts(year, c(2014))) + s(year, k = 5) + s(year, k = 5, by = as.numeric(age==0))

q sub-models:

~s(replace(age, age > 3, 3), k = 3)

~factor(age)

~factor(replace(age, age > 3, 3))

~s(age, k=4, by = breakpts(year, 2012))

~ s(replace(age,age>3,3),k = 3, by = breakpts(year, 2012))

SR sub-models:

~factor(year)

~s(year, k = 4)

An F_{bar} range between age 1 and 3 was used. Age 0 was removed from the survey index.

The best model (combination of the sub-models in bold) was chosen on the basis of retrospective analysis and residuals.

In the best model, it was assumed a change in survey catchability from 2012, due to a change in the survey period, and a change in the behaviour of the fleet from 2014, due to the enforcement of the regulation that does not allow to fishermen to fish within the 3 nautical miles (where the smaller individuals are generally distributed). A specific term in the F sub-model is dedicated to the fitting of the F at age 0.

Results

The F time series estimated by a4a ranges between 1.10 and 0.48, with an overall decrease with time. In the last years, the model estimates a strong increase in SSB and recruitment (Table 6.2.3.5; Figure 6.2.3.3).

The fishing mortality at age shows the maximum values in age 2 and 3, decreasing in time (Table 6.2.3.6; Figure 6.2.3.4).

In general, the fitting of the commercial catch at age and survey index at age is acceptable (Figure 6.2.3.5). The internal consistency of both catches and survey indices is good (Figure 6.2.3.8), particularly for ages 0,1 and 2 which dominate the population.

The residuals are generally small (between -3 and 3) and quite random distributed by age, but a signal of a trend in the fit is shown by the bubble plot of residuals in the last years (Figures 6.2.3.6 and 6.2.3.7).

Table 6.2.3.5 Red mullet in GSAs 17 and 18. Results of the final a4a run: F_{bar} (1-3) overall, SSB, Recruitment and total biomass.

Year	F_{bar} (1-3)	Recruitment (thousands)	SSB (tons)	Total biomass (tons)
2006	1.10	1526151	5602	18432
2007	1.08	1526428	5370	17855
2008	1.06	1558639	5280	17737
2009	1.03	1654707	5035	16982
2010	0.99	1836043	5126	17249
2011	0.95	2101404	5375	16044
2012	0.91	2411939	5319	19058
2013	0.85	2685772	6764	23109
2014	0.77	2828251	7645	26216
2015	0.67	2793590	9015	26220
2016	0.57	2619415	10306	27956
2017	0.48	2391365	11433	25860

Table 6.2.3.6 Red mullet in GSAs 17 and 18. Results of the final a4a run: F-at-age.

Year	0	1	2	3	4+
2006	0.00	0.17	1.00	2.13	2.49
2007	0.00	0.15	1.04	2.05	1.88
2008	0.00	0.14	1.06	1.98	1.56
2009	0.00	0.15	1.04	1.90	1.56
2010	0.00	0.19	0.97	1.82	1.89
2011	0.00	0.25	0.90	1.72	2.25
2012	0.00	0.28	0.87	1.59	2.12
2013	0.00	0.27	0.87	1.41	1.52
2014	0.00	0.25	0.87	1.20	0.94
2015	0.00	0.23	0.82	0.96	0.57
2016	0.01	0.23	0.74	0.73	0.35
2017	0.02	0.23	0.65	0.55	0.22

Table 6.2.3.7 Red mullet in GSAs 17 and 18. Results of the final a4a run: Stock numbers-at-age.

Year	0	1	2	3	4+
2006	1526151	475163	179101	41122	3500
2007	1526428	372300	196473	39167	3415
2008	1558639	372450	157852	41167	3670
2009	1654707	380334	159672	32405	4284
2010	1836044	403707	161219	33663	3798
2011	2101404	447635	164362	36481	3969
2012	2411939	511616	172226	39862	4569
2013	2685772	586661	190085	43034	5730
2014	2828251	653467	219459	47275	7756
2015	2793590	688248	250217	54703	11482
2016	2619415	678957	267625	65315	18286
2017	2391365	633687	265319	75827	29535

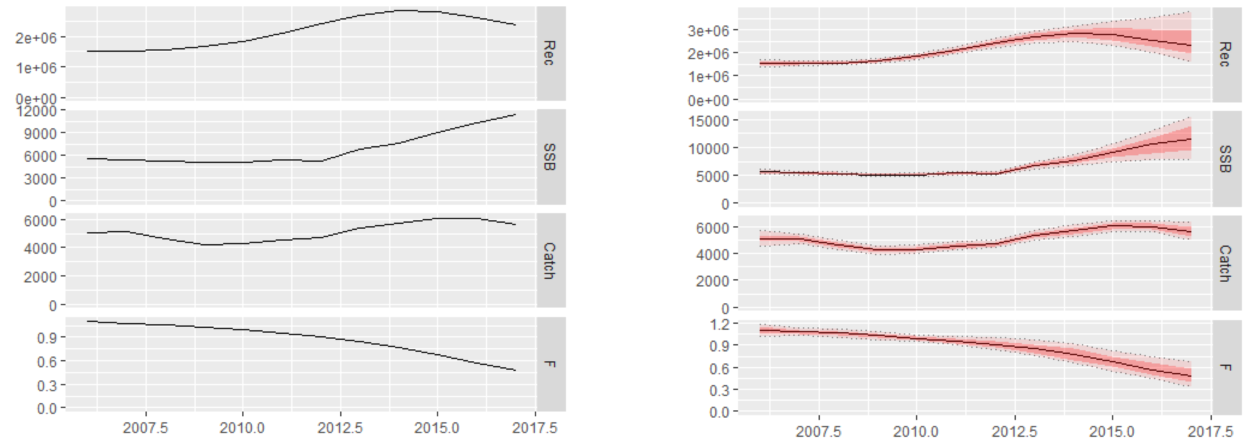


Figure 6.2.3.3 Red mullet in GSAs 17 and 18. Summary of the results.

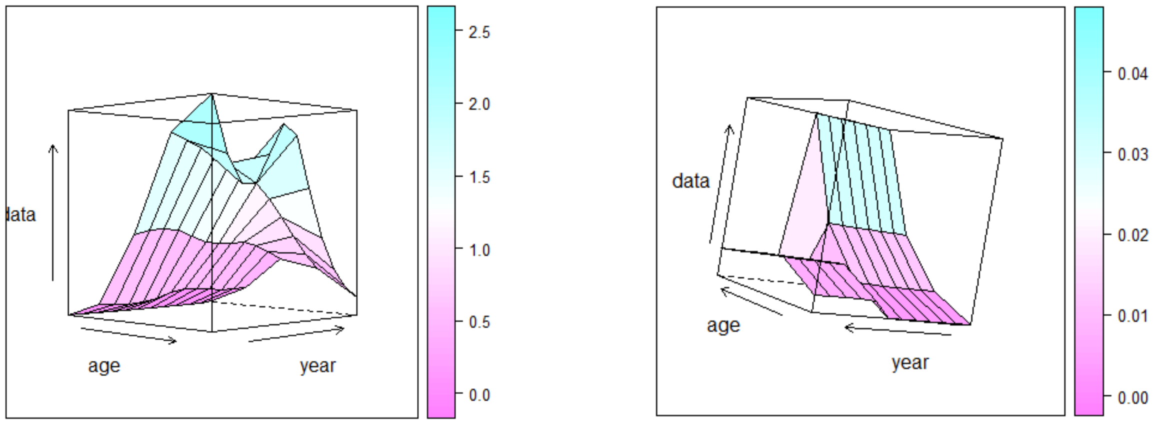


Figure 6.2.3.4 Red mullet in GSAs 17 and 18. Fishing mortality (left) and catchability (right) by age and year.

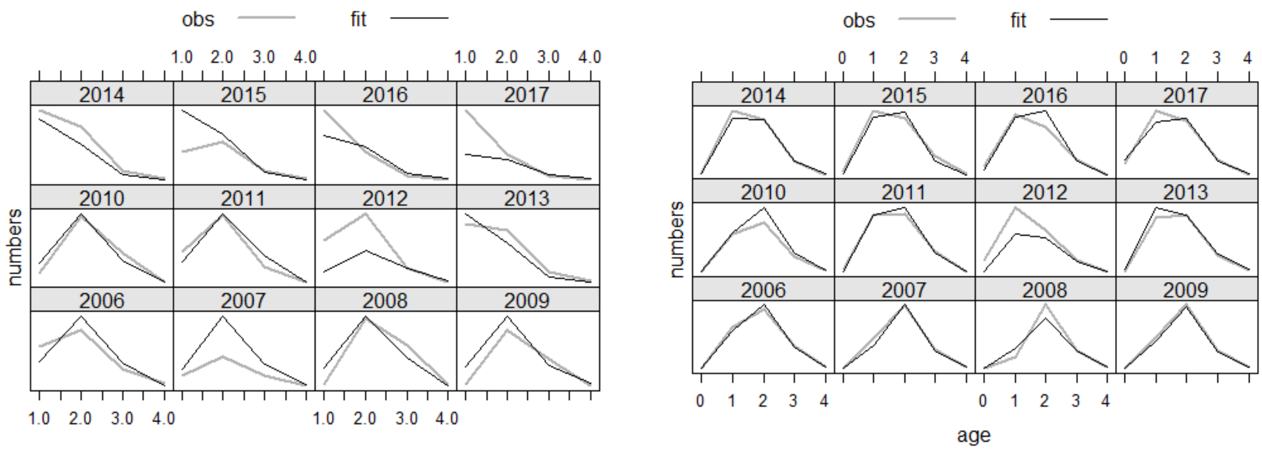


Figure 6.2.3.5 Red mullet in GSAs 17 and 18. Comparison between observed and fitted catch (left) and index (right) at age

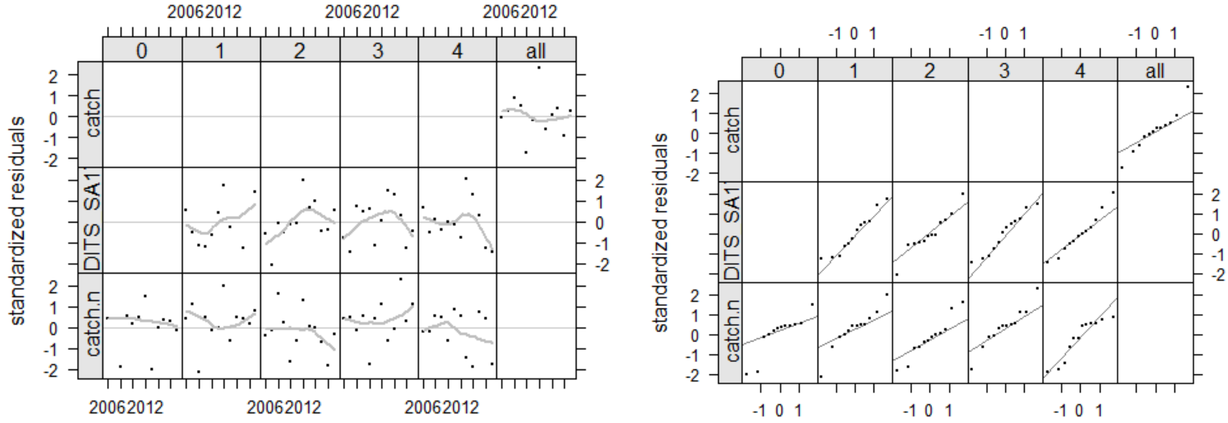


Figure 6.2.3.6 Red mullet in GSAs 17 and 18. Log-residuals (left) and qq-plot (right) of catch and abundance indices by age.

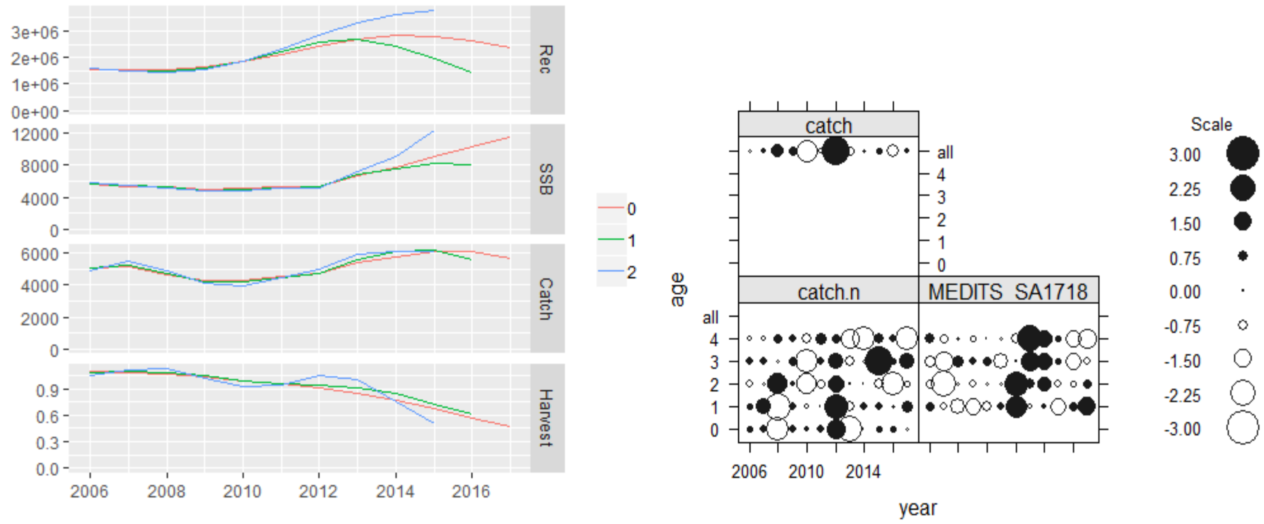


Figure 6.2.3.7 Red mullet in GSAs 17 and 18. Retrospective analysis and bubble plot of residuals.

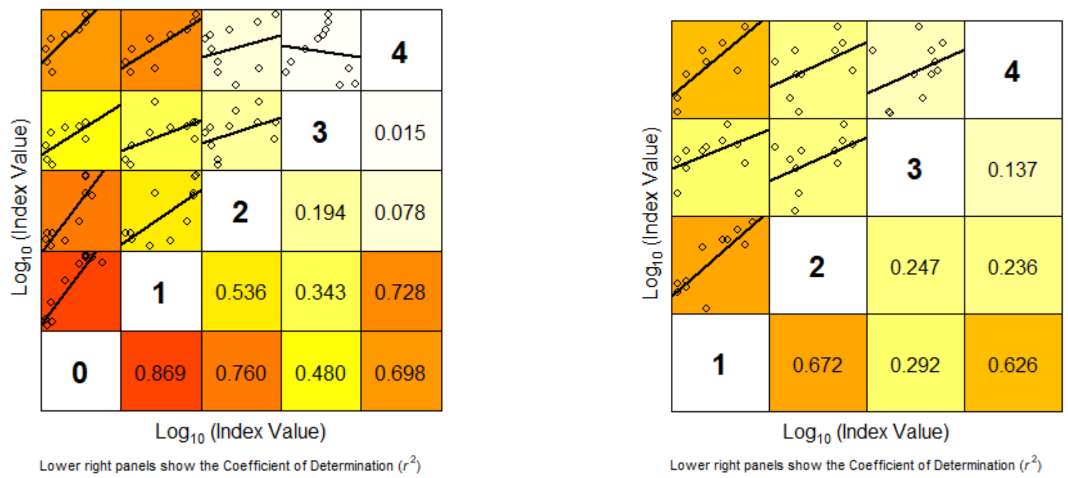


Figure 6.2.3.8 Red mullet in GSAs 17 and 18. Internal consistency in the catches (left) and the index (right).

6.2.4 Reference Points

An $F_{0.1}$ of 0.41 was estimated using the FLBRP package. Considering that the F estimated by the a4a model for 2017 is 0.48, the stock is considered slightly overexploited.

6.2.5 Short term Forecast and Catch Options

A deterministic short-term prediction for the period 2018 to 2020 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

The input parameters for the deterministic short-term predictions for the period 2016 to 2018 were the same used for the a4a stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} terminal from the a4a assessment was used due to a clear decreasing trend in F in the whole time series.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the last 7 years (2535525 thousand individuals). It was decided to use the last 7 years as they showed a clear shift in recruitment abundance compared to the first part of the time series. Catch in 2017 is 5652 from the a4a assessment, catch in 2018 is 5773 asuuming Status quo F based F 2017 for F in 2018.

Table 6.2.5.1 Red mullet in GSAs 17-18. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2020	SSB 2019	SSB 2020	Change SSB 2018-2020 (%)	Change Catch 2017-2019 (%)
Zero catch	0.0	0.00	0.0	0.0	15141.9	21396.0	80.0	-100.0
High long term yield ($F_{0.1}$)	0.9	0.41	5083.2	5423.5	12537.5	13334.4	12.2	-10.1
F_{upper}	1.2	0.56	6519.2	6301.8	11714.1	11374.0	-4.3	15.3
F_{lower}	0.6	0.27	3606.0	4228.7	13340.0	15501.5	30.4	-36.2
Status quo	1.0	0.48	5746.2	5862.9	12162.9	12411.0	4.4	1.7
Different Scenarios	0.1	0.05	699.1	969.8	14808.0	20188.7	69.8	-87.6
	0.2	0.10	1366.5	1827.4	14482.7	19064.4	60.4	-75.8
	0.3	0.14	2003.9	2584.9	14165.8	18017.2	51.6	-64.5
	0.4	0.19	2612.9	3253.2	13857.0	17041.1	43.3	-53.8
	0.5	0.24	3194.8	3841.9	13556.1	16131.0	35.7	-43.5
	0.6	0.29	3751.2	4359.6	13262.9	15281.9	28.6	-33.6
	0.7	0.33	4283.3	4814.0	12977.2	14489.3	21.9	-24.2
	0.8	0.38	4792.4	5212.0	12698.8	13749.1	15.7	-15.2
	0.9	0.43	5279.7	5559.8	12427.4	13057.5	9.8	-6.6
	1.1	0.52	6193.1	6126.2	11905.1	11806.2	-0.7	9.6
	1.2	0.57	6621.4	6354.0	11653.8	11240.1	-5.4	17.1
	1.3	0.62	7031.9	6550.4	11408.7	10710.1	-9.9	24.4
	1.4	0.67	7425.6	6718.8	11169.8	10213.5	-14.1	31.4
	1.5	0.71	7803.3	6862.3	10936.9	9747.9	-18.0	38.1
	1.6	0.76	8165.7	6983.8	10709.8	9311.3	-21.7	44.5
	1.7	0.81	8513.8	7085.7	10488.3	8901.4	-25.1	50.6
	1.8	0.86	8848.1	7170.4	10272.3	8516.6	-28.4	56.5
	1.9	0.90	9169.3	7239.7	10061.7	8154.9	-31.4	62.2
	2.0	0.95	9478.1	7295.5	9856.2	7814.9	-34.3	67.7

6.3 NORWAY LOBSTER IN GSA 17-18

Last assessment was carried out during STECF EWG 17-15 using a production model (SPICT)

6.3.1 STOCK IDENTITY AND BIOLOGY

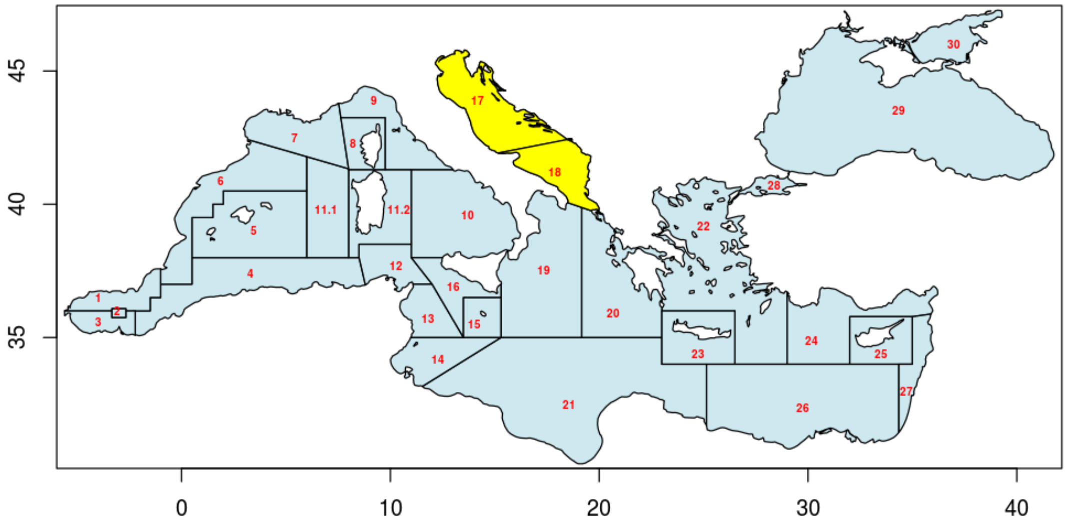


Figure 6.3.1.1 Norway lobster in GSA 17 and 18. Geographical location of GSAs 17-18.

The main biological traits of the species in the Adriatic have been revised during EWG 15-16. One of the most relevant features pointed out is the occurrence of a sub-unit of individuals living in the Pomo-Jabuka Pit area, and featured by significant differences in the biological parameters (e.g. growth and maturity) in comparison with specimens distributed on the continental shelf of the GSA 17 (Froglia and Gramitto, 1988). EWG 15-16 discussed the implications of such spatial configuration for the assessment of the stock identifying as a pre-requisite the availability of catch/landings data split by fishing grounds (Pomo Pit, continental shelf areas) to properly apply age-based models.

In GSA 18 the stock is basically distributed on the continental slope, deeper than 200m depth, both on the eastern (Montenegro, Albania) and western side (Italy, Puglia) of the GSA.

The distribution of nursery grounds and spawning areas has been analysed during the EU project MEDISEH (MAREA tender project). In GSA 17 denser and persistent patches of small specimens occur in the Pomo Pit area (MEDISEH project report, 2013). Aggregations of adults were identified in GSA 17 offshore the SW coasts, in the Pomo Pit, and in north and south Croatian waters (Figure 6.3.1.2). In GSA 18 the more persistently abundant adult aggregations occur on the SE and SW edges of the South Adriatic Pit (Figure 6.3.1.3).

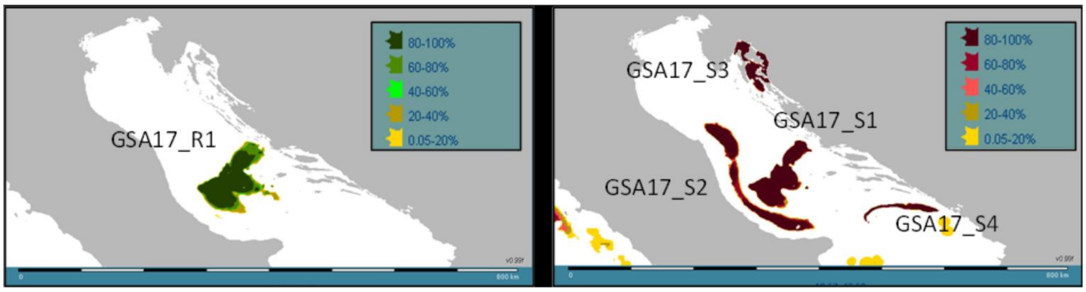


Figure 6.3.1.2 Norway lobster in GSA 17 and 18. Position of persistent nursery (left) and spawning areas (right) in GSA 17 as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

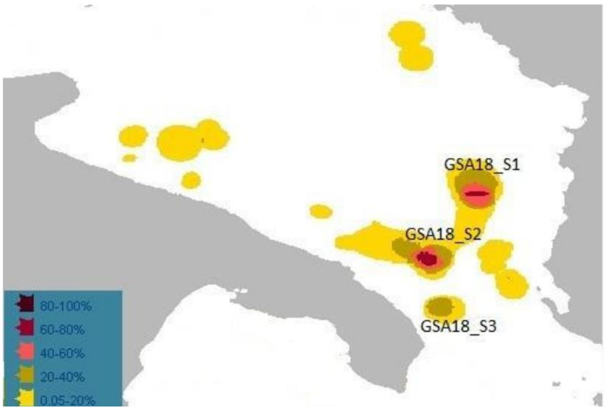


Figure 6.3.1.3 Norway lobster in GSA 17 and 18 Position of persistent spawning areas in GSA 18 of as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

Growth

A summary of the knowledge on growth and maturity pattern of Norway lobster in Adriatic is provided in the EWG 15-16 report (STECF, 2015). A comparison of the growth curves for Norway lobster in GSAs 17 and 18 is showed in Figure 6.3.1.1.4 was done during EWG 18-16. Nevertheless, in the first 2 years growth rate between shelf (Outside Pomo) and slope (Pomo) in GSA17 appears similar, maximum length in Pomo appears lower as probably determined by a slow growth after the first 2 years of life. However, high mortality rate of adults and or dispersion/migration toward other areas cannot be excluded. In this regard, it would be important to explore the connectivity of the Pomo Pit sub-unit with the stock in GSA 18. The Pomo Pit system is in fact well connected with the South Adriatic slope through a narrow channel between 100 and 150 m. In Table 6.3.1.1 VBGF parameters are reported.

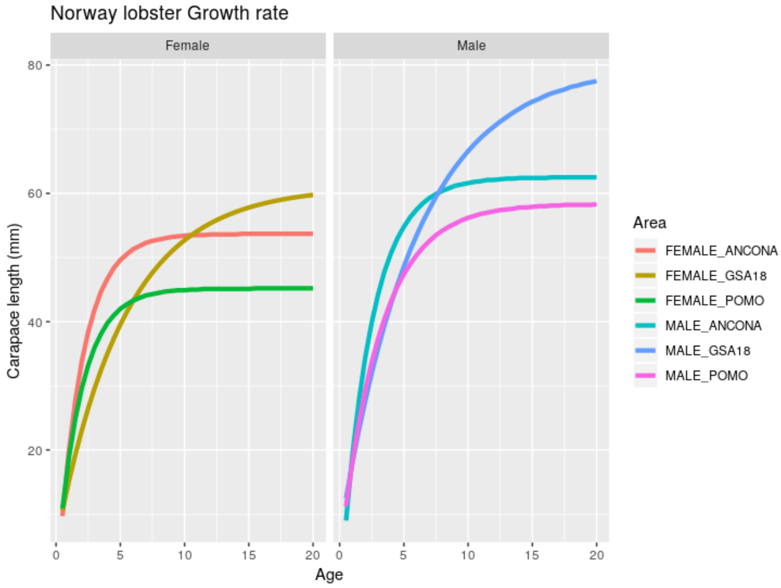


Figure 6.3.1.4 Norway lobster in GSA 17 and 18. Growth curves of males and females of Norway lobster in GSAs 17 and 18.

Table 6.3.1.1 Norway lobster in GSAs 17 and 18. VBGF growth parameters of males and females of Norway lobster in GSAs 17 and 18.

GSA	Linf(mm)	k	t0	sex	area	Reference
17	62.51	0.432	0.142	male	ancona	Froglia_Gramitto
17	53.68	0.528	0.123	female	ancona	Froglia_Gramitto
17	58.35	0.324	-0.159	male	pomo	Froglia_Gramitto
17	45.16	0.528	-0.023	female	pomo	Froglia_Gramitto
18	80.00	0.170	-0.500	male	GSA18	Data_Call_2018
18	60.36	0.190	-0.500	female	GSA18	Data_Call_2018

Maturity

Maturity size of females from available studies in GSAs 17 and 18 are reported in Table 6.3.1.2.

Table 6.3.1.2 **Norway lobster in GSA 17 and 18.** Length-at-maturity information on Norway lobster females from studies carried out in Adriatic Sea (from EWG 15-16 report).

- GSA 17 – Pomo Pit: ~ 26 mm CL (Froglia and Gramitto, 1979; Gramitto and Froglia, 1980; Froglia and Gramitto, 1981; IMBC et al., 1994; Orsi Relini et al., 1998; DCF data);
- GSA 17 – outside Pomo Pit: ~30 – 32.5 mm CL (Froglia and Gramitto, 1979; Gramitto and Froglia, 1980; Froglia and Gramitto, 1981; IMBC et al., 1994; Orsi Relini et al., 1998);
- GSA 18: between 25 mm and 34.8 mm CL, depending on the year (Marano et al., 1998a; Ungaro et al., 1999; DCF data).

GSA18 female maturity vectors provided with the official data call 2018 and available during EWG18-16 are showed in Table 6.3.1.1.3. No data of maturity by age were provided for GSA17 (ITA and HRV). A mean value was used in applying the analytical assessment.

Table 6.3.1.3 Norway lobster in GSA 17 and 18. Maturity vector of Norway lobster females from Data Call 2018 in GSA18.

	GSA18 Female							
ageclass	2002	2005	2008	2010	2013	2016	2017	Mean
0			0	0	0	0	0	0.00
1		1	0.231	0.093	0.082	0.114	0.02	0.26
2	1	1	0.722	0.815	0.815	0.869	0.805	0.86
3	1	1	0.971	1	0.998	1	1	1.00
4	1	1	1	1	1	1	1	1.00
5	1	1	1	1	1	1	1	1.00
6			1	1	1		1	1.00

Female maturity vectors for the whole GSA17 were obtained using information on sex and maturity stage collected during the MEDITS survey (MEDITS Instruction Manual Ver.9 – 2017. http://www.sibm.it/MEDITS%202011/principaledownload.htm). Data were subset between Pomo and Outside Pomo according to water depth and hauls position. A GLM model was fitted on MEDITS maturity data. Finally, carapace lengths at age predicted using VBGF parameters for the two areas (Table 6.3.1.1) were used to obtain final maturity vector by age according to the predicted values of GLM model by length.

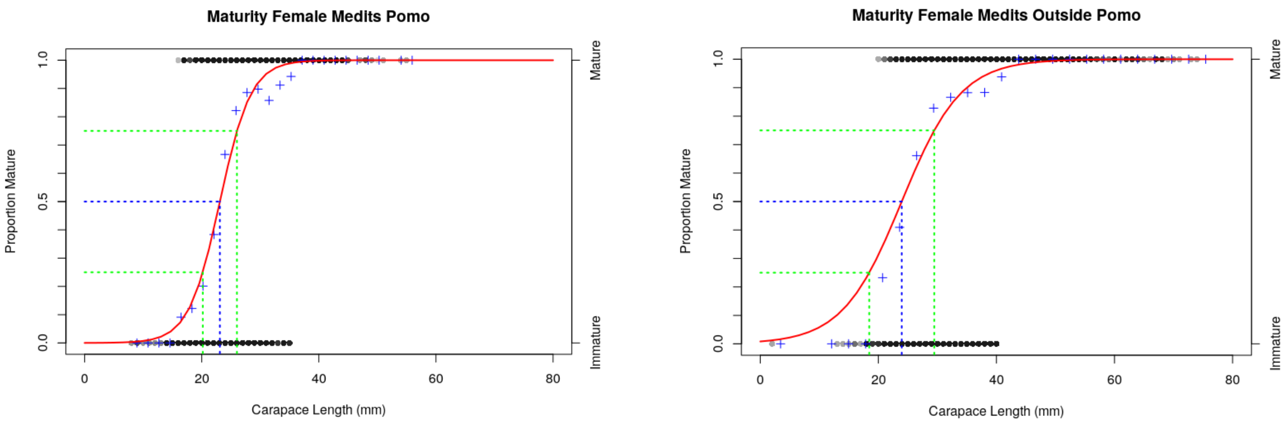


Figure 6.3.1.5 Norway lobster in GSA 17 and 18. Maturity ogives estimated using MEDITS maturity data of Norway lobster in GSA17. Dashed blue line represents L50 while dashed green lines represent L25 and L75.

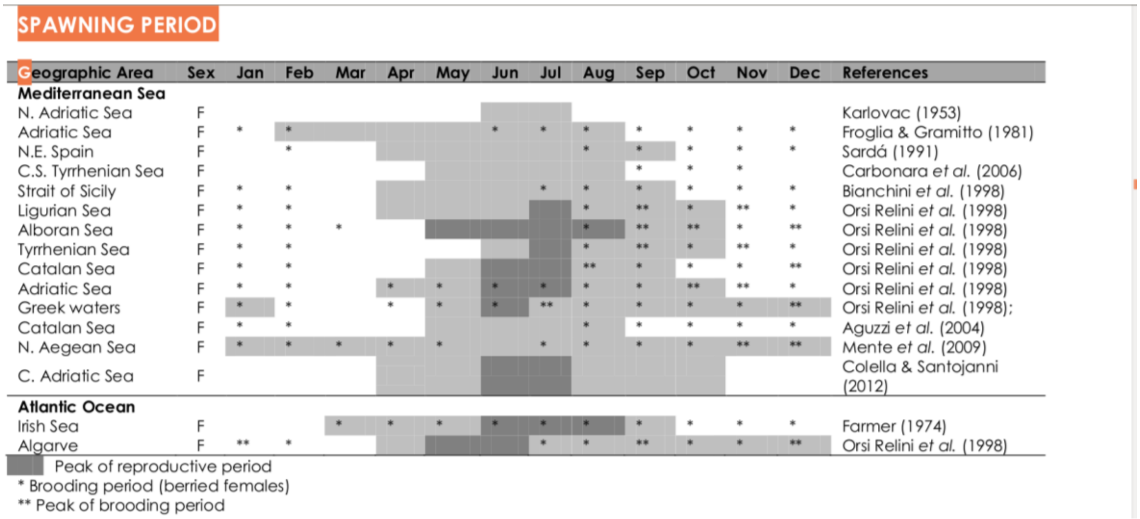
Table 6.3.1.4 Norway lobster in GSA 17 and 18. L25, L50 and L75 values for Norway lobster females estimated using MEDITS maturity data available for the whole GSA17 (ITA+HRV). Estimation was done separately by Pomo and Outside Pomo Pit.

GSA17 (ITA+HRV)	L25%	L50%	L75%
Pomo	20.18	23.10	26.01
Outside Pomo	18.45	23.95	29.46

Table 6.3.1.5 Norway lobster in GSA 17 and 18. Age maturity vectors values for Norway lobster females of Pomo and Outside Pomo Pit.

	Proportion of mature female	
Ages	Pomo	Outside Pomo
0	0.01	0.05
1	0.67	0.68
2	0.98	0.95
3	1.00	0.98
4	1.00	0.99
5	1.00	1.00
6	1.00	1.00

Figure 6.3.1.6 Norway lobster in GSA 17 and 18. Spawning period for Norway lobster in Mediterranean areas.



Natural mortality

Natural mortality vectors were estimated by sex and area according to Chen and Watanabe formula. Natural mortality final vector by GSA was obtained weighting sex vectors according to abundance by sex. Stock natural mortality vector was obtained weighting GSAs vectors by the total abundance (Catch numbers) in each GSA (Table 6.3.1.6).

Table 6.3.1.6 Norway lobster in GSA 17 and 18. Natural mortality vectors values for Norway lobster females of Pomo and Outside Pomo Pit according to Chen and Watanabe method.

Ages	GSA17Pomo18	GSA17OutsidePomo18
0	1.50	2.01
1	0.73	0.84
2	0.50	0.50
3	0.40	0.39
4	0.36	0.33
5	0.35	0.31
6+	0.42*	0.37*

*Values increase due to plus group effect in slicing length in ages by sex

Mean weight

Mean weight vectors were estimated by sex and area according to length weight relationships available through DCF data call 2018. Mean weight final vector by GSA was obtained weighting sex vectors according to abundance by sex. Mean weight vector was obtained weighting GSAs vectors by the total abundance in each GSA.

Table 6.3.1.7 Norway lobster in GSA 17 and 18. Mean weight (kg) vectors values for Norway lobster females of Pomo and Outside Pomo Pit according to DCF data call 2018 Length weight relationships a and b parameters.

Ages	GSA17Pomo18	GSA17OutsidePomo18
0	0.002	0.004
1	0.008	0.016
2	0.017	0.027
3	0.034	0.041
4	0.058	0.060
5	0.080	0.079
6+	0.129	0.140

6.3.2 DATA

6.3.2.1 CATCH (LANDINGS AND DISCARDS)

No data were available for Slovenia because Norway lobster it isn't caught in Slovenian fishery grounds. In the following sections Croatian, Italian and Albania data in term of landings and discards in weight are reported. For Croatia and Italy available size structures by gear are reported (no data were available for Albania during the meeting)

LANDINGS

Landings in weight

Landings data by gear for Croatia were available for the period 2013-2017.

Table 6.3.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2017.

Total landings in weight (tonnes)					
Gear	2013	2014	2015	2016	2017
FPO	0	17.171	29.935	29.669	38.656
OTB	278.167	325.217	268.615	202.798	158.713
Total	**278.167**	**342.388**	**298.550**	**232.467**	**197.369**

Table 6.3.2.1.2 Norway lobster in GSA 17 and 18. Proportion of Croatian landings data by gear for the period 2013-2017.

Proportion by gear type					
Gear	2013	2014	2015	2016	2017
FPO	0.00	0.05	0.10	0.13	0.20
OTB	1.00	0.95	0.90	0.87	0.80

Nevertheless, otter trawler (OTB) represents the most important gear in catching Norway Lobster, the relative importance of traps and pots (FPO) increase in time.

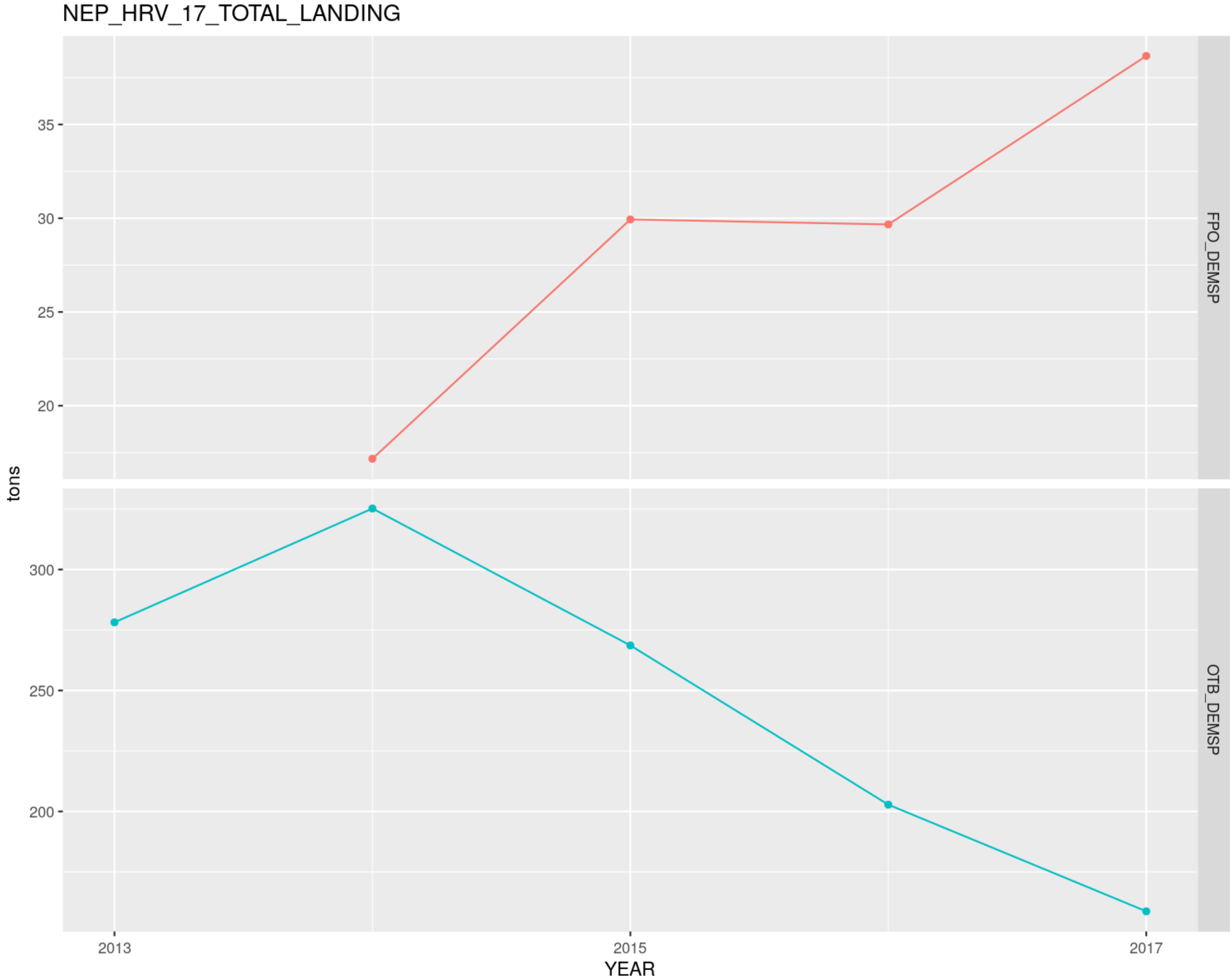


Figure 6.3.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2017.

Landings data by gear for Italy (GSA17) were available for the period 2006-2017.

Table 6.3.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2017.

Total landings in weight (tonnes)	
Year	OTB
2006	1462.369
2007	1259.422
2008	1270.441
2009	1378.788
2010	1215.949
2011	936.590
2012	801.527
2013	606.542
2014	528.592
2015	450.143
2016	359.472
2017	288.000

Otter trawler (OTB) is the only gear catching Norway Lobster in the GSA17 Italian side. There is a clear decreasing trend in the landings from almost 1500 tonnes in 2006 to just under 300 tonnes in 2017.

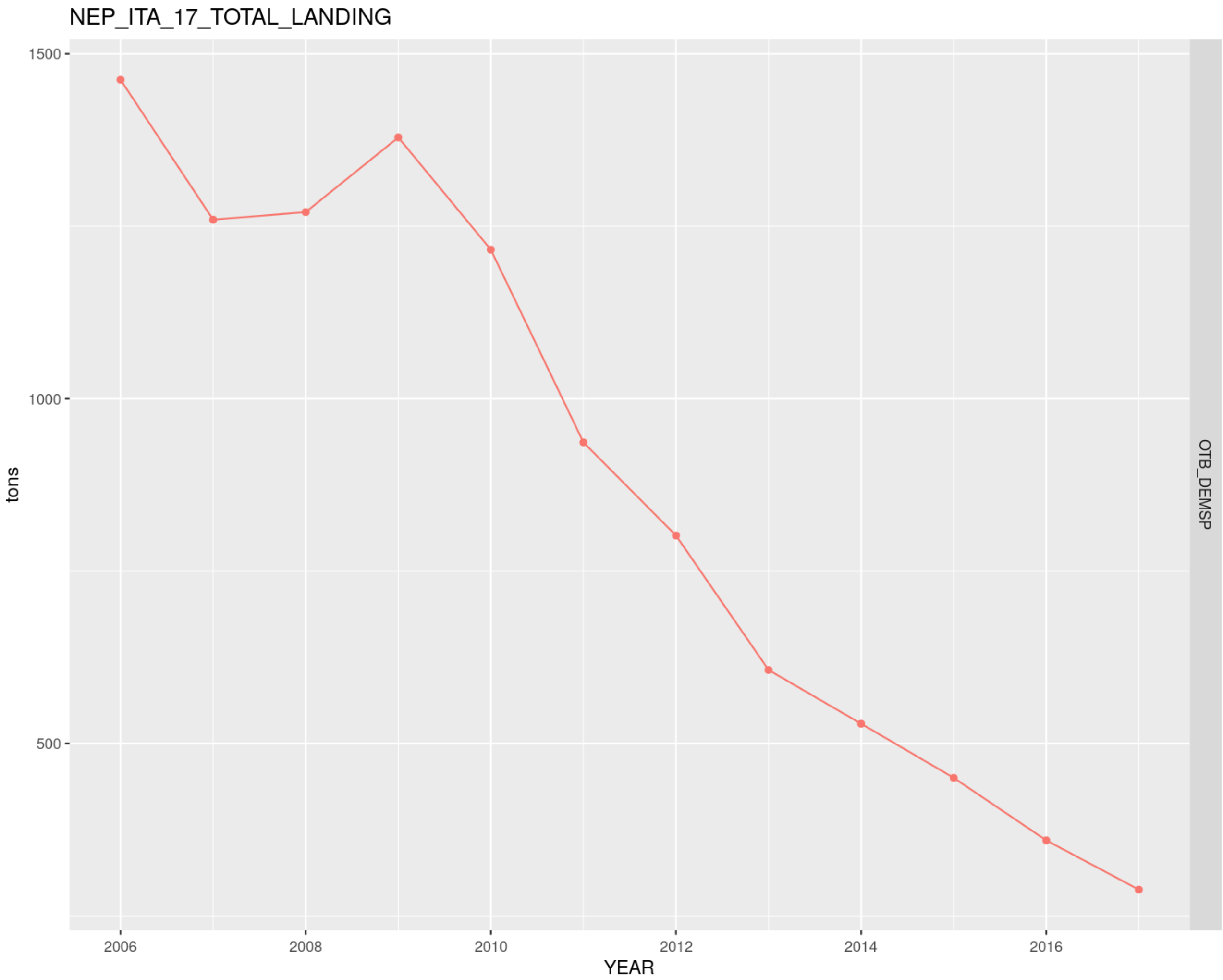


Figure 6.3.2.1.2 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2017.

Data by gear for Italy (GSA18) were available for the period 2002-2017.

Table 6.3.2.1.4 Norway lobster in GSA 17 and 18. Italian (GSA18) landings data by gear for the period 2002-2017.

Total landings in weight (tonnes)				
year	-1	GNS	OTB	**Total**
2002	36.317		442.156	**478.473**
2003	141.766	5.528	1039.255	**1186.550**
2004			1218.430	**1218.430**

2005		2.274	1196.402	**1198.676**
2006	0.477	9.551	1436.620	**1446.647**
2007		14.743	1299.891	**1314.634**
2008		9.836	1002.964	**1012.800**
2009			1092.894	**1092.894**
2010			1023.423	**1023.423**
2011			759.169	**759.169**
2012			458.704	**458.704**
2013			833.833	**833.833**
2014			444.717	**444.717**
2015			442.753	**442.753**
2016			395.072	**395.072**
2017			556.178	**556.178**

Table 6.3.2.1.5 Norway lobster in GSA 17 and 18. Proportion of Italian (GSA18) landings data by gear for the period 2002-2017.

Proportion by gear type			
year	-1	GNS	OTB
2002	0.076	0.000	0.924
2003	0.119	0.005	0.876
2004	0.000	0.000	1.000
2005	0.000	0.002	0.998
2006	0.000	0.007	0.993
2007	0.000	0.011	0.989
2008	0.000	0.010	0.990
2009	0.000	0.000	1.000

2010	0.000	0.000	1.000
2011	0.000	0.000	1.000
2012	0.000	0.000	1.000
2013	0.000	0.000	1.000
2014	0.000	0.000	1.000
2015	0.000	0.000	1.000
2016	0.000	0.000	1.000
2017	0.000	0.000	1.000

The most important gear (lowest percentage 87%) for the catch Norway lobster in GSA18 is the otter trawler (OTB). Very few catches derived from gillnet (GNS) and only in 2003, and 2005 to 2008 and from an undefined gear (-1) in 2002-2003.

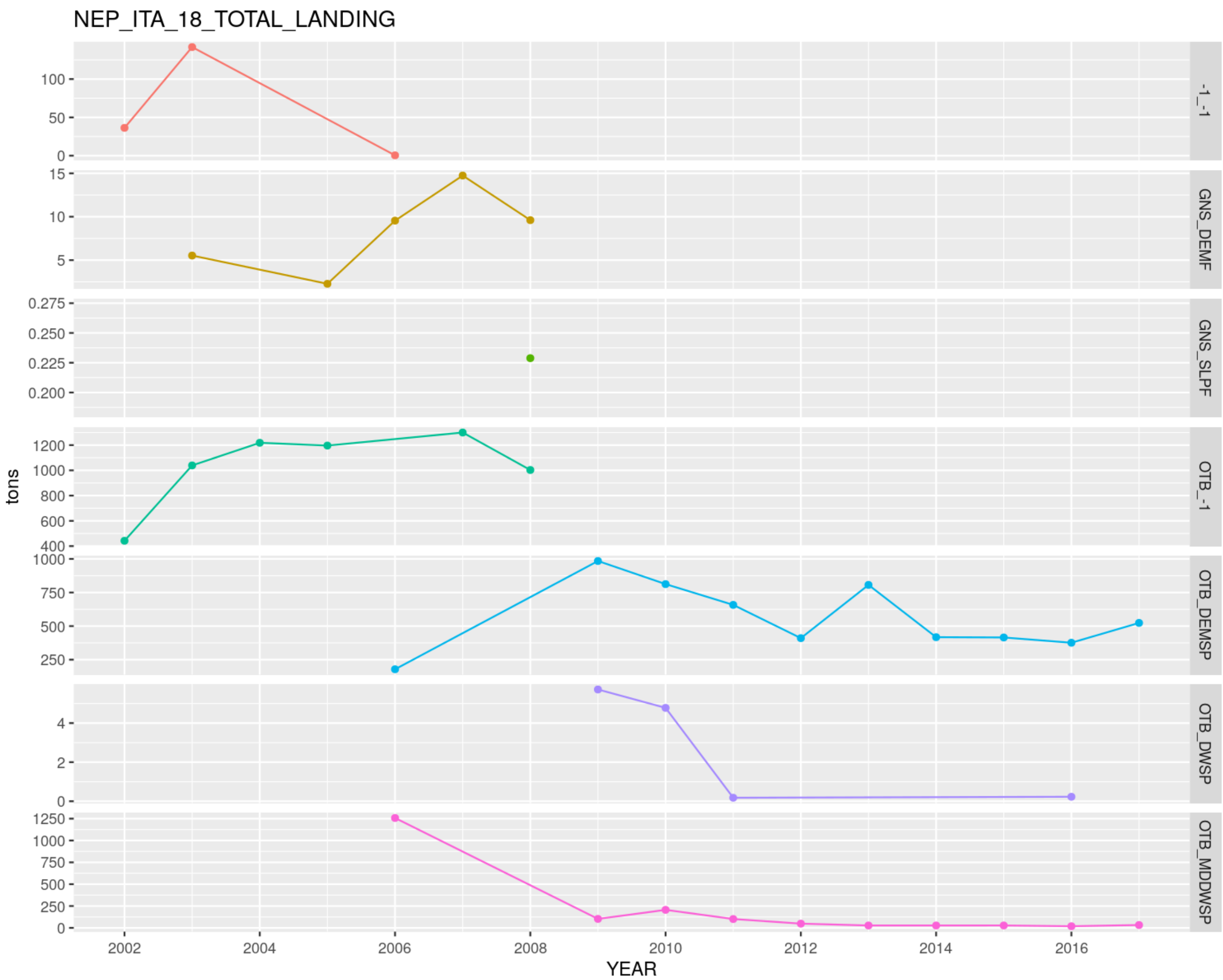


Figure 6.3.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA18) landings data by gear for the period 2002-2017.

During STECF EWG18-16 Albania revised landings were available for the period 2012-2017.

Table 6.3.2.1.6 Norway lobster in GSA 17 and 18. Albanian (GSA18) landings data for the period 2012-2017.

Albania_GSA18_NEP_Landings	
Year	Tonnes
2012	435
2013	398
2014	400
2015	405
2016	411
2017	389

Size distributions of the landings

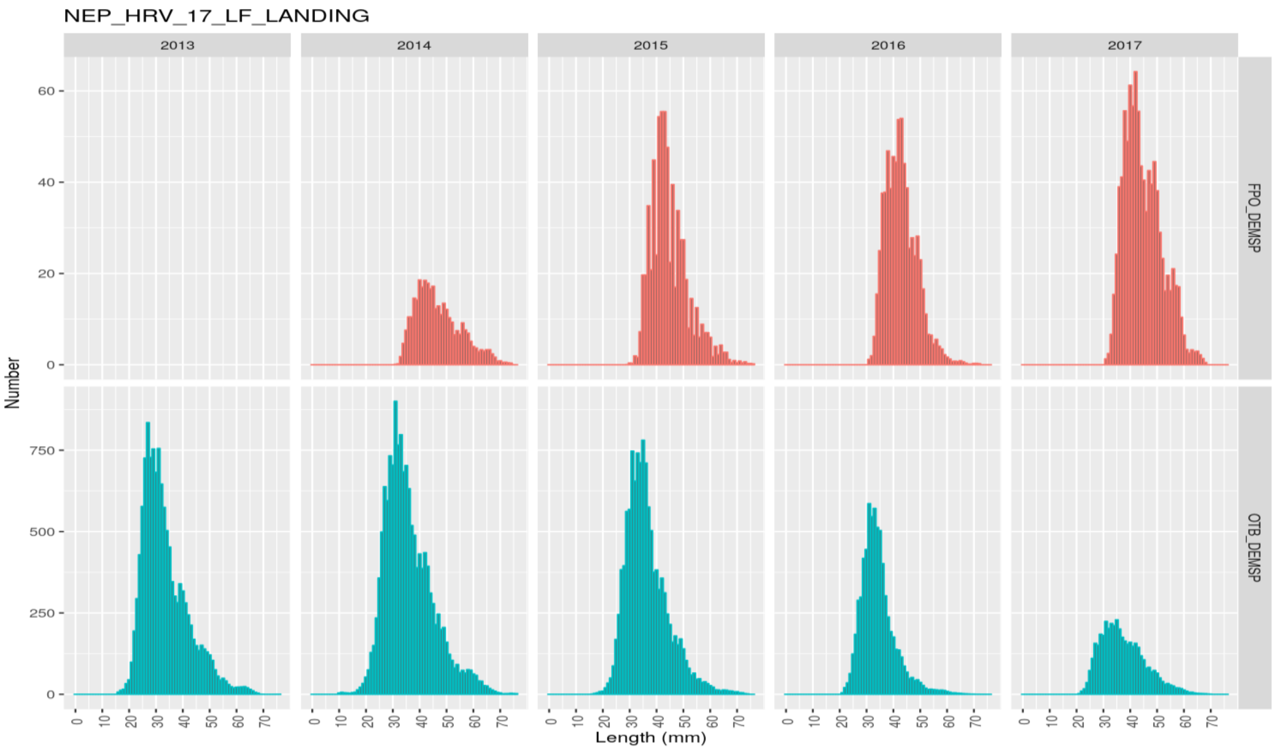


Figure 6.3.2.1.4 Norway lobster in GSA 17 and 18. Length frequency distributions of the Croatian landings by gear in the period 2013-2017.

Because of the consistency in the shape of length distributions in 2012-2017 (Figure 6.3.2.1.5 and Table 6.3.2.1.7) and a quite good agreement between DCF landings and FAO landings (Figure 6.3.2.1.6) missing length frequency distributions from 2006 to 2012 were reconstructed according to a mean distribution of the available years raised for the total landings in each year.

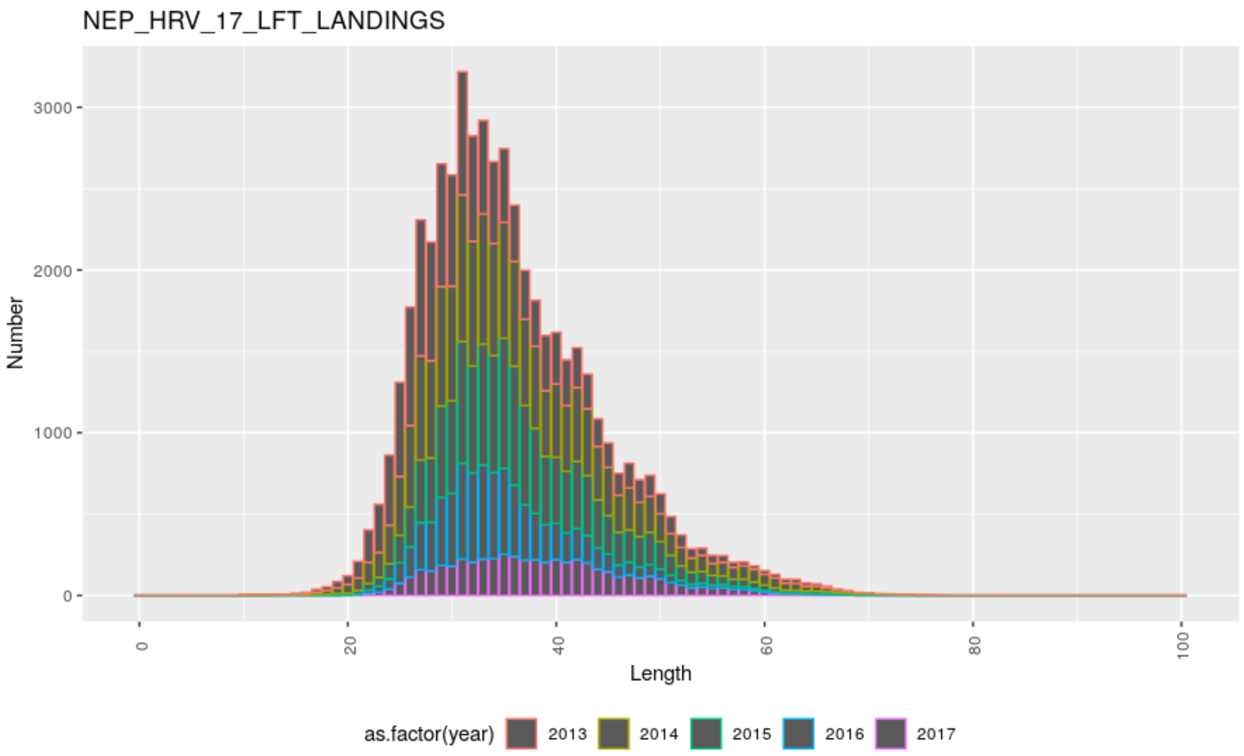


Figure 6.3.2.1.5 Norway lobster in GSA 17 and 18. Total length frequency distributions of the Croatian landings in the period 2013-2017.

Table 6.3.2.1.7 Norway lobster in GSA 17 and 18. Kolmogorov-Smirnoff test to compare length frequency distributions.

KS$results

	Ds	p
2013 vs 2014	0.157	1
2013 vs 2015	0.237	1
2013 vs 2016	0.198	1
2013 vs 2017	0.297	1
2014 vs 2015	0.081	1
2014 vs 2016	0.098	1
2014 vs 2017	0.150	1
2015 vs 2016	0.111	1
2015 vs 2017	0.126	1
2016 vs 2017	0.232	1

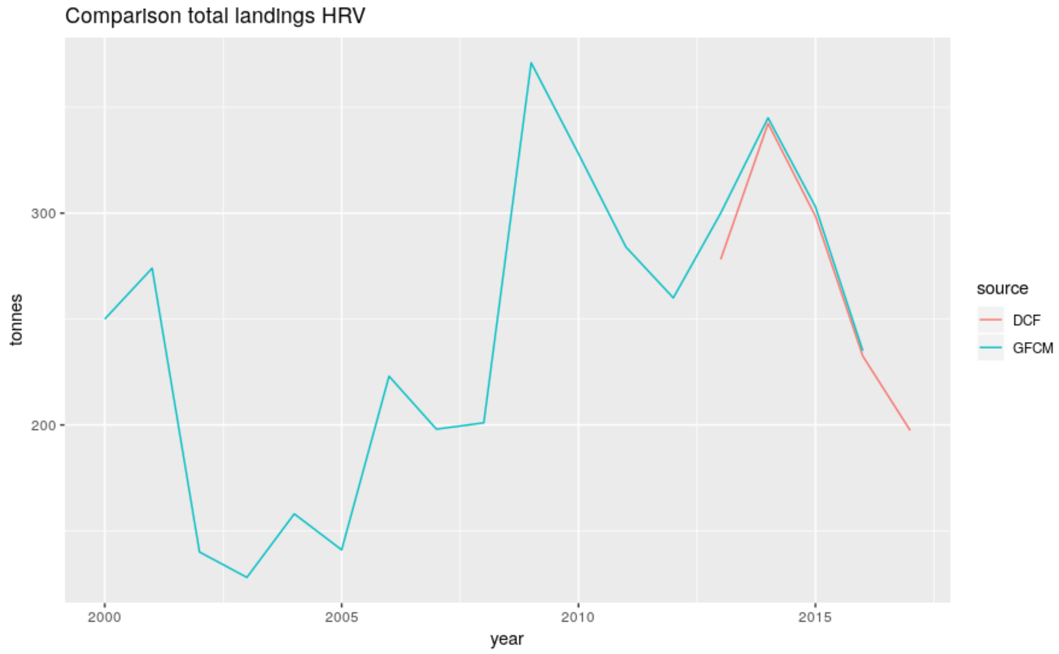


Figure 6.3.2.1.6 Norway lobster in GSA 17 and 18. Comparison between Croatian total landings from DCF and FAO-GFCM database.

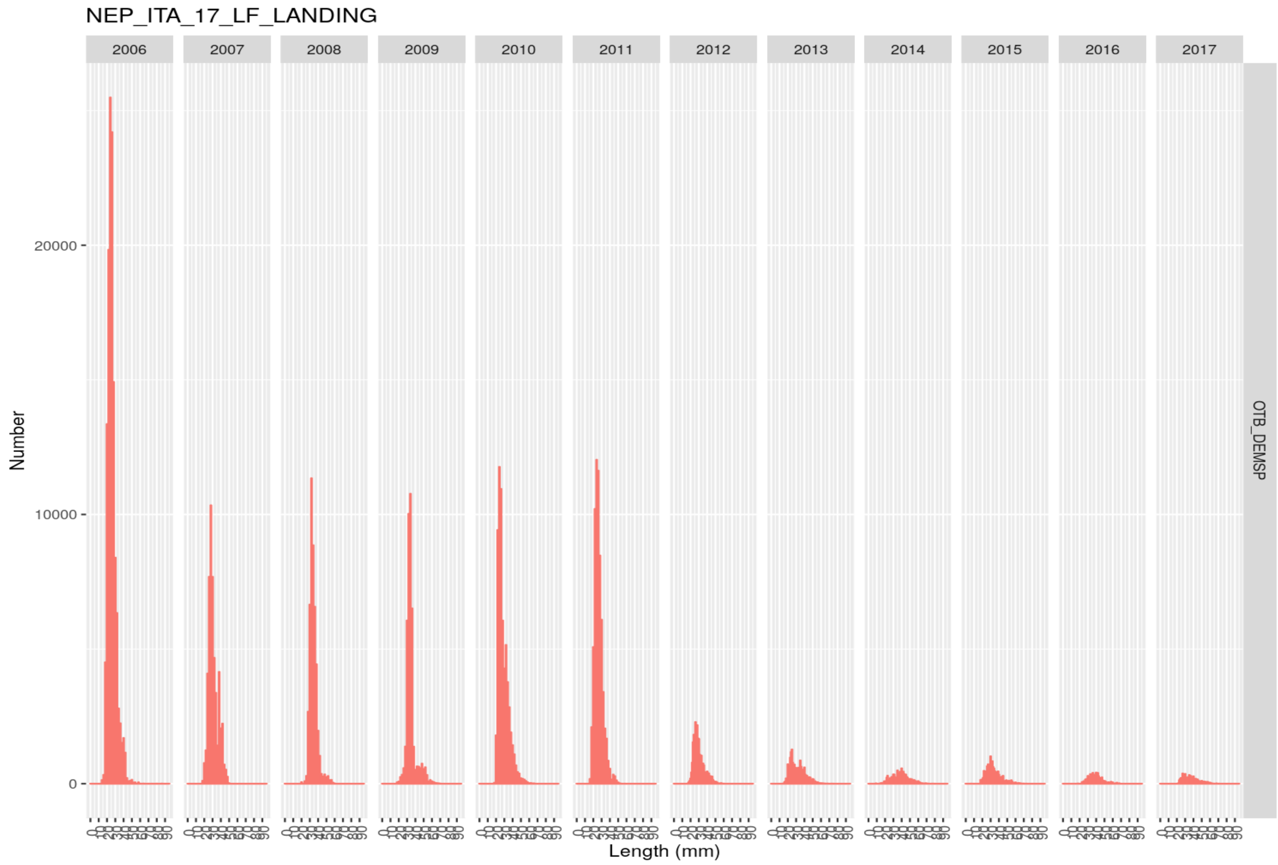


Figure 6.3.2.1.7 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA17) landings by gear in the period 2006-2017.

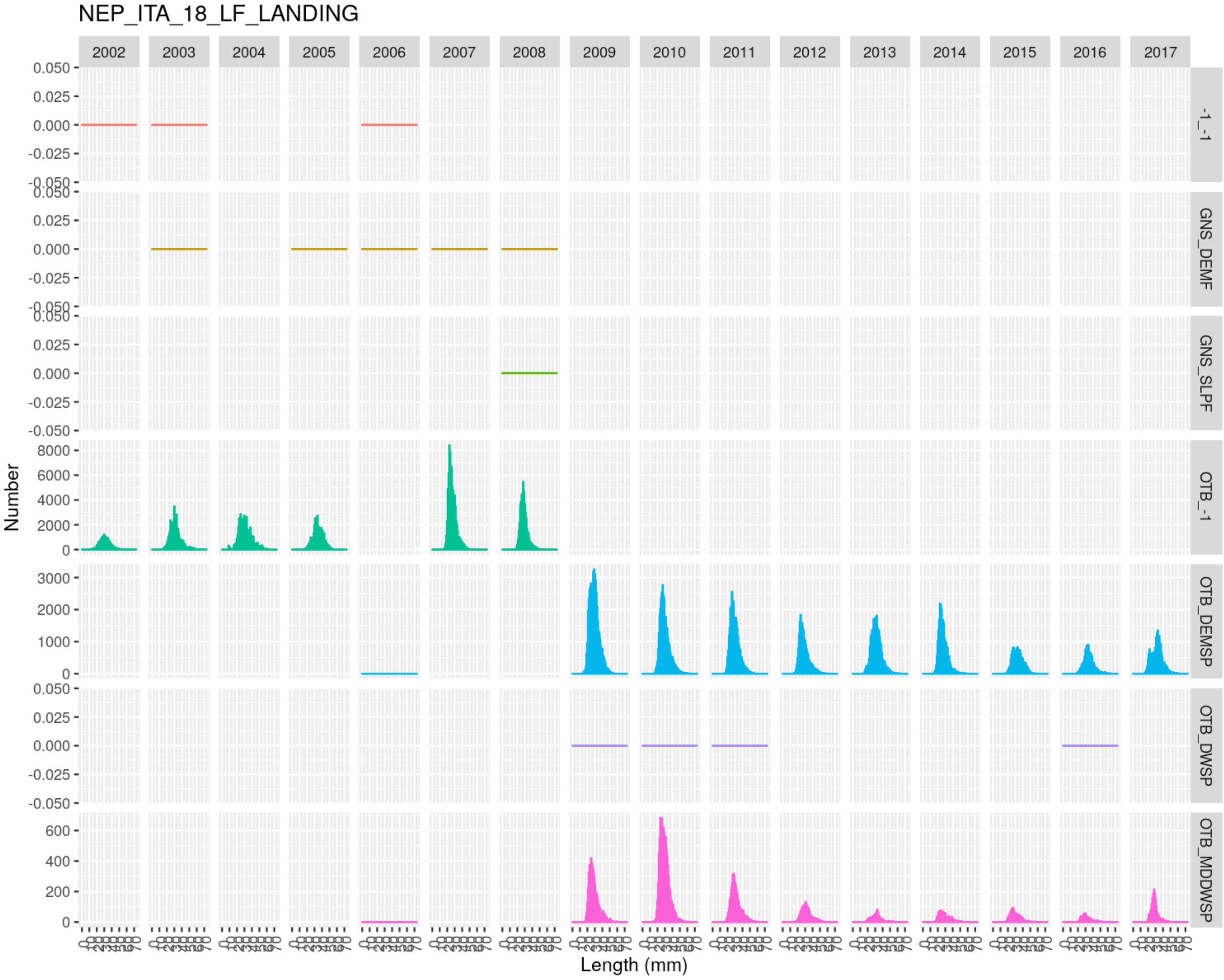


Figure 6.3.2.1.8 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA18) landings by gear in the period 2002-2017.

DISCARDS

This species is rarely discarded. OTB is the only gear in which discards was observed in all the areas.

Discards in weight

Discards data by gear for Croatia were available for the period 2013-2017.

Table 6.3.2.1.8 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2013-2017.

Total discards in weight (tonnes)					
Gear	2013	2014	2015	2016	2017
OTB	0.275	0.145	0.171	0.047	0.164

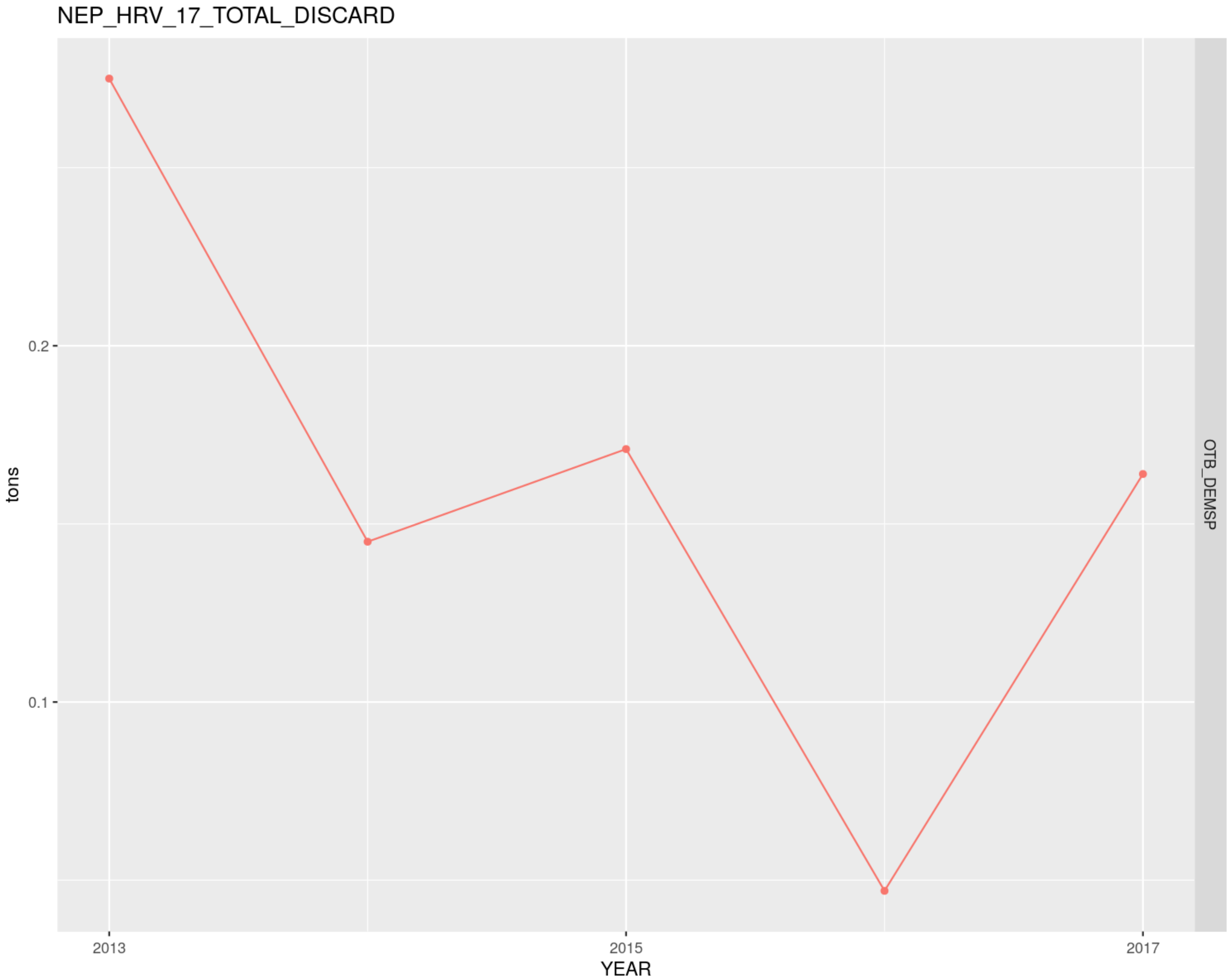


Figure 6.3.2.1.9 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2012-2017.

In Italy (GSA17) discard was observed only in 2011 (4.92 tonnes OTB).

Table 6.3.2.1.9 Norway lobster in GSA 17 and 18. Italian (GSA18) discards data by gear for the period 2009-2017.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
OTB	66.77	6.23	0.83	3.99	2.27	5.07	2.05	0.74	2.95

Discards values were always very low except in the 2009 (66 tonnes).

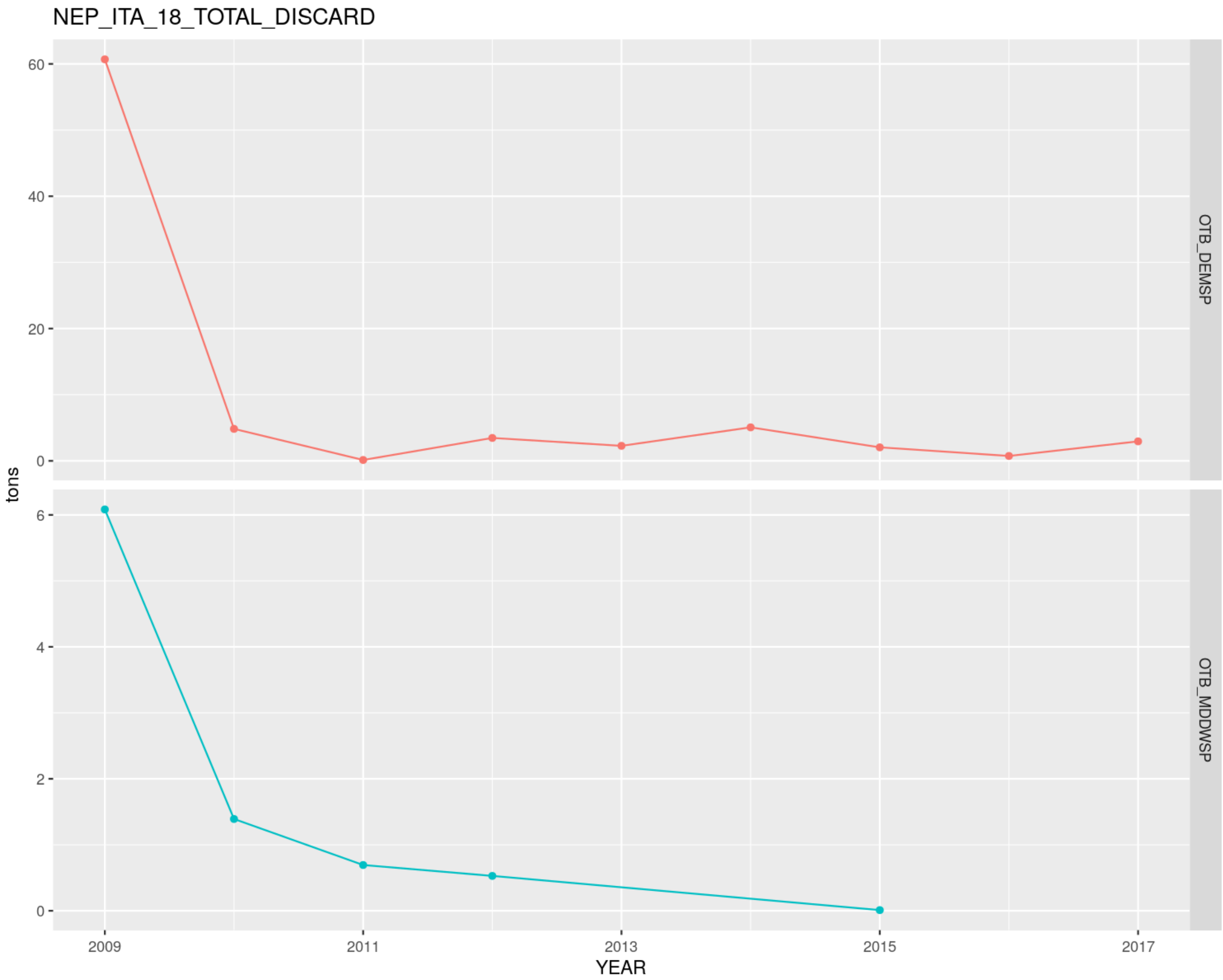


Figure 6.3.2.1.10 Norway lobster in GSA 17 and 18. Italian (GSA18) discards data by gear for the period 2009-2017.

Size distributions of the discards

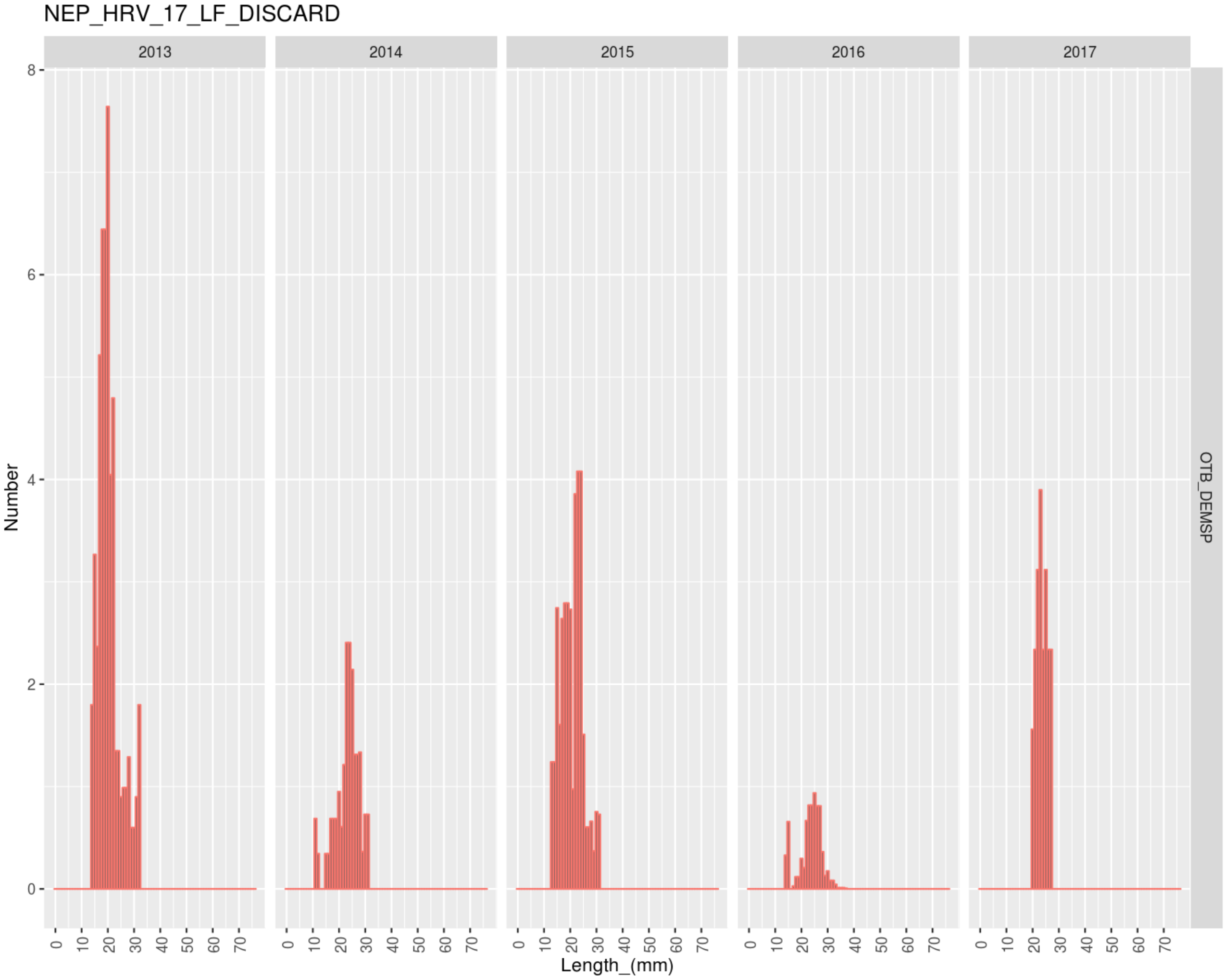


Figure 6.3.2.1.11 Norway lobster in GSA 17 and 18. Length frequency distributions of the Croatian discards by gear in the period 2013-2017.

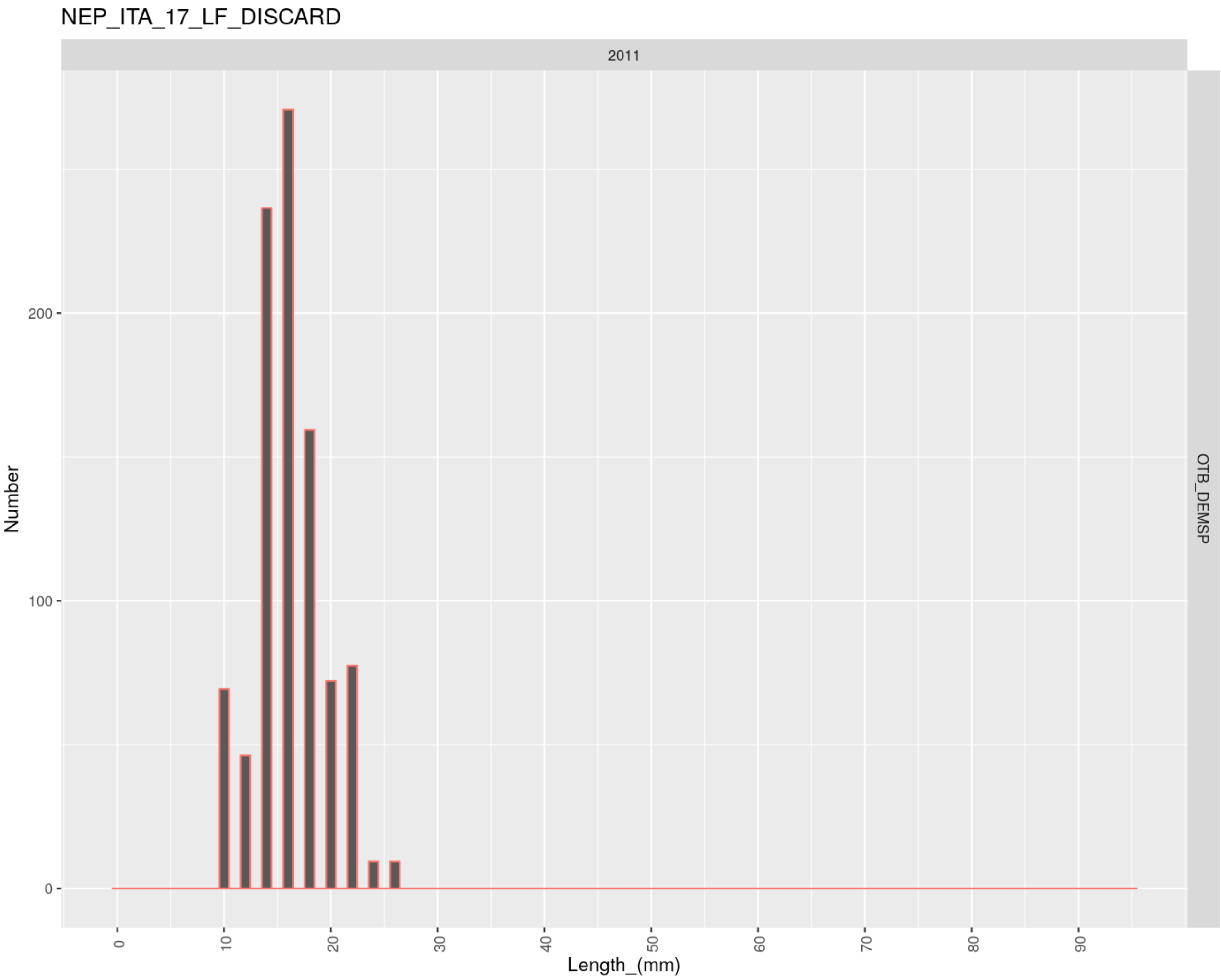


Figure 6.3.2.1.12 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA17) discards by gear in 2011.

Figure 6.3.2.1.13 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA18) discards by gear in the period 2009-2017.

In the production model (SPICT) landings series was updated according to revised Albanian landings (2012-2017) and to Italian and Croatian DCF landings (2006-2017).

In the analytical assessment both data in landings and discards available from 2006 onward were used. Catches data were computed according to both (Table 6.3.2.1.10 and Figure 6.3.2.1.14).

Table 6.3.2.1.10 Norway lobster in GSAs 17 and 18. Landings and discards data by GSA for the period 2006-2017.

	ITA17		HRV17		ITA18		ALB18	GSA17_18			
year	landings	discards	landings	discards	landings	discards	landings	**Total landings**	**Total discards**	Total catches	%discards
2006	1462.37	0.00	223.00	0.00	1446.65	0.00	0.00	**3132.02**	**0.00**	3132.02	0.000
2007	1259.42	0.00	198.00	0.00	1314.63	0.00	0.00	**2772.06**	**0.00**	2772.06	0.000
2008	1270.44	0.00	201.00	0.00	1012.80	0.00	0.00	**2484.24**	**0.00**	2484.24	0.000
2009	1378.79	0.00	371.00	0.00	1092.89	**66.77**	0.00	**2842.68**	**66.77**	2909.46	2.295
2010	1215.95	0.00	328.00	0.00	1023.42	6.23	0.00	**2567.37**	**6.23**	2573.60	0.242
2011	936.59	4.92	284.00	0.00	759.17	0.83	0.00	**1979.76**	**5.75**	1985.51	0.290
2012	801.53	0.00	260.00	0.00	458.70	3.99	435.00	**1955.23**	**3.99**	1959.23	0.204
2013	606.54	0.00	278.17	0.28	833.83	2.27	398.00	**2116.54**	**2.55**	2119.09	0.120
2014	528.59	0.00	342.39	0.15	444.72	5.07	400.00	**1715.70**	**5.21**	1720.91	0.303
2015	450.14	0.00	298.55	0.17	442.75	2.05	405.00	**1596.45**	**2.23**	1598.67	0.139
2016	359.47	0.00	232.47	0.05	395.07	0.74	411.00	**1398.01**	**0.79**	1398.80	0.056
2017	288.00	0.00	197.37	0.16	556.18	2.95	389.00	**1430.55**	**3.11**	1433.66	0.217

In red are reported Croatian landings data extracted from FishStatJ FAO database.

In green outliner discards data from GSA18.

In black bold landings and discards data used in the analytical assessments

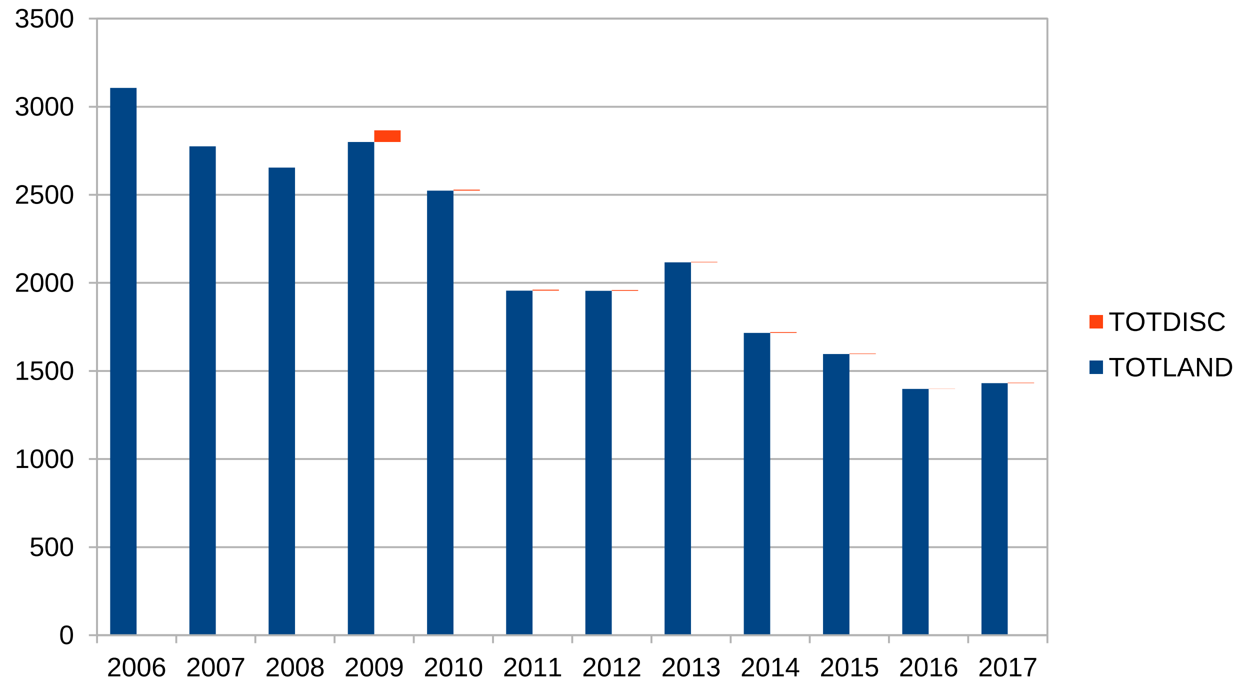


Figure 6.3.2.1.14 Norway lobster in GSA 17 and 18. Total catches in GSAs 17 and 18 in the period 2006-2017.

6.3.2.2 EFFORT

Norway lobster in GSAs 17 and GSA 18 is exploited mostly by bottom trawlers. A small amount of catch is produced by small-scale vessels using traps in the northern-eastern Adriatic channels as well as by gillnetters in GSA 18. For this fleet Norway lobster is a minor by-catch of boats targeting hake on the continental slope. Effort data for the Italian trawl fleet (OTB) in GSA18 is available since 2002, in GSA17 since 2004 whereas nominal effort data of Croatian trawlers cover the period 2012-2017 (Table 6.3.2.2.1-3, Figure 6.3.2.2.1). The temporal trend shows an increasing value in 2017 which follows a relevant reduction in the nominal effort (KW*fishing days) of the Italian trawl fleet both in GSA 17 and GSA 18. The Croatian fleet effort was quite stable in the last three years.

Table 6.3.2.2.1 Norway lobster in GSA 17 and 18. Nominal effort in kW days for Croatian OTB_DEMSP and traps (FPO) fleets.

Gear	2012	2013	2014	2015	2016	2017
FPO	289746.89	344195.49	268384.79	339356.40	369306.81	475708.74
OTB_DEMSP	866145.01	1118003.66	1284830.60	1526596.82	1601315.32	1581140.12

Table 6.3.2.2.2 Norway lobster in GSA 17 and 18. Nominal effort in kW days for Italian (GSA17) OTB_DEMSP fleet.

Year	OTB_DEMSP
2004	21087676
2005	20335938
2006	18657299
2007	18308149
2008	19842127
2009	18788561
2010	17935158
2011	16434634
2012	13751962
2013	12597554
2014	14117196
2015	13671010
2016	14181818
2017	16467374

Table 6.3.2.2.3 Norway lobster in GSA 17 and 18. Nominal effort in kW days for Italian (GSA18) OTB_DEMSP fleet.

	-1	GNS				OTB			
year	-1	-1	DEMF	DEMSP	SLPF	-1	DEMSP	DWSP	MDDWSP
2002	7277279.22	1722336.01				17112021.58			
2003	4416994.38	1002933.17				14530792.97			
2004				1457047.00			1210239.00		13241221.00
2005	4295.00			2035861.00			525746.00		13024315.00
2006	45187.00			1785782.00			4042496.00		10702114.00
2007	3474.00			1280477.00			2822672.00		10017537.00
2008	20159.00			878105.00	16218.00		10723146.00	130964.00	609325.00
2009	0.00			1181419.00	23657.00		12291687.00	108546.00	1478134.00
2010				570405.00			9386636.00	124777.00	2344855.00
2011	18934.00			450946.00			9883344.00	46554.00	1399545.00
2012	4334.00			395458.00			9225895.00		596064.00
2013	73049.00			777758.00			10087518.00		424108.00
2014	80913.00			207752.00			7286976.00		449344.00
2015	37879.00			1129811.00			6158791.00		854825.00
2016	64715.00			1023952.00			7390323.00	23090.00	409572.00
2017	69271.75		151715.40		491.31		10228570.60	73280.50	1095821.19

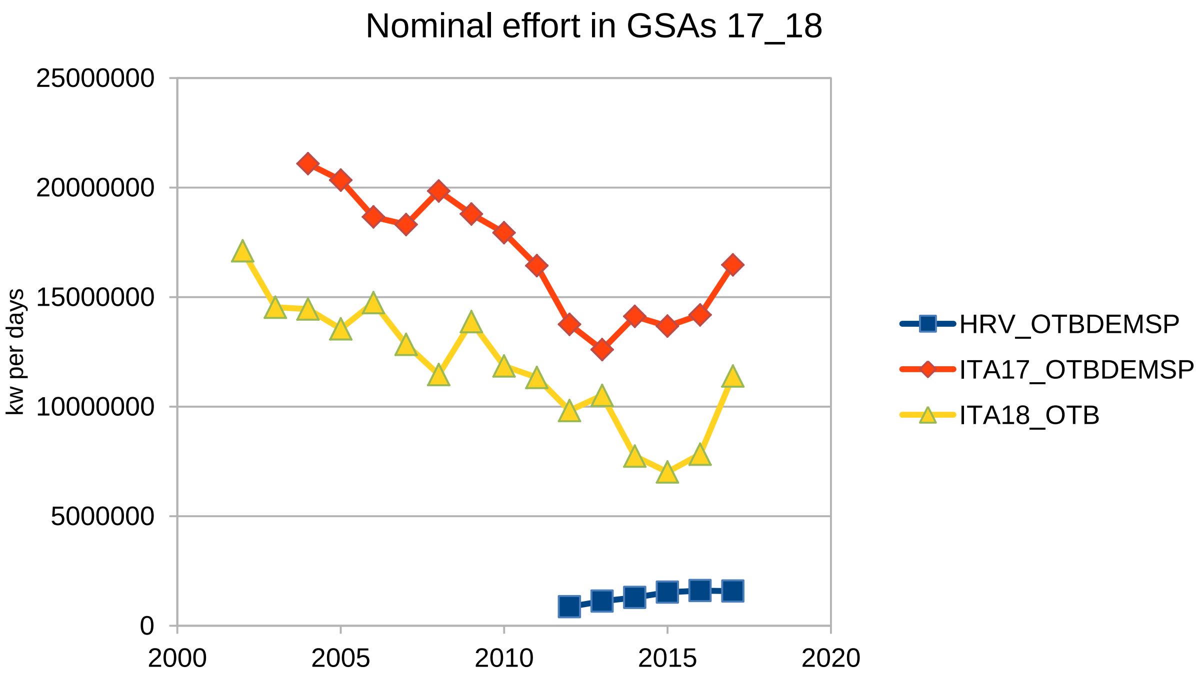


Figure 6.3.2.2.1 Norway lobster in GSA 17 and 18. rend in nominal effort of trawlers in GSAs 17_18

Table 6.3.2.2.4 Norway lobster in GSA 17 and 18. Trend in nominal effort of trawlers in GSAs 17_18

	HRV_OTBDEMSP	ITA17_OTBDEMSP	ITA18_OTB
2002			17112022
2003			14530793
2004		21087676	14451460
2005		20335938	13550061
2006		18657299	14744610
2007		18308149	12840209
2008		19842127	11463435
2009		18788561	13878367
2010		17935158	11856268
2011		16434634	11329443
2012	866145	13751962	9821959
2013	1118004	12597554	10511626

2014	1284831	14117196	7736320
2015	1526597	13671010	7013616
2016	1601315	14181818	7822985
2017	1581140	16467374	11397672

6.3.2.3 SURVEY DATA

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were carried out yearly (May - July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time (Figure 6.3.2.3.1). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was used throughout the time series. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size, complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardized to square kilometre, using the swept area method. Abundance and biomass indices were recalculated, based on the DCF data call.

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Only hauls noted as valid were used, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

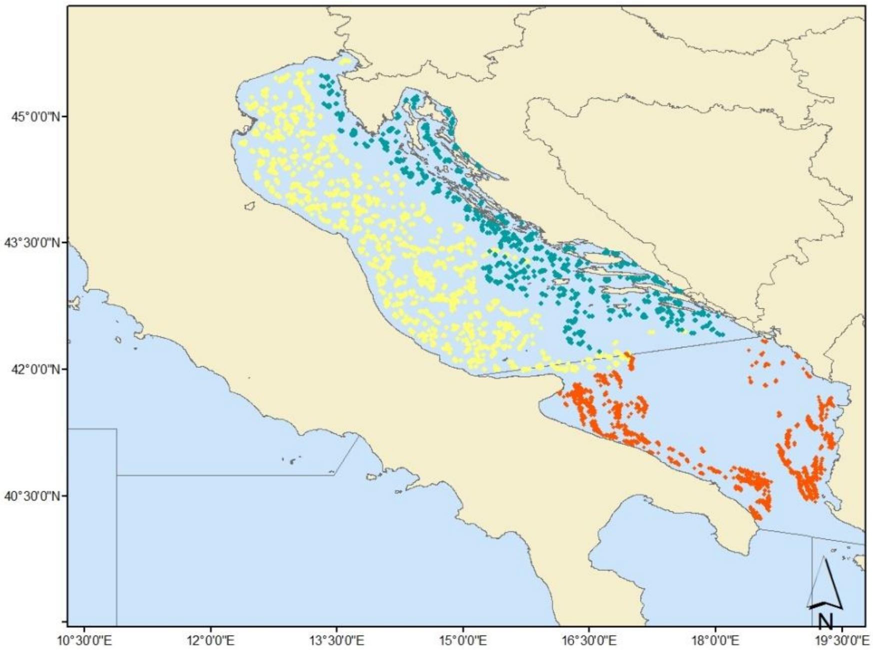


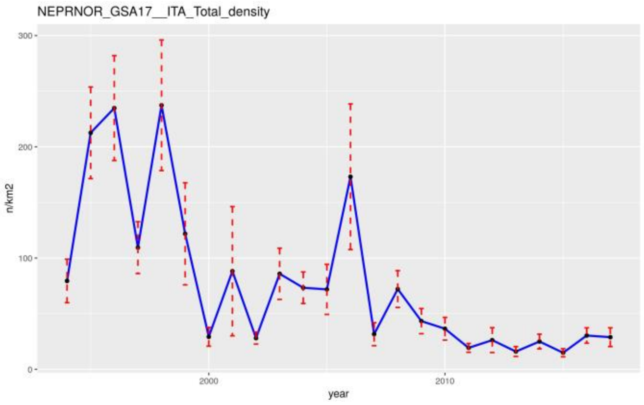
Figure 6.3.2.3.1 Norway lobster in GSA 17 and 18. MEDITS trawl survey, distribution of the hauls carried out in the area.

Trends in abundance and biomass

Abundance and biomass indices of MEDITS display a decreasing temporal trend in GSA 17 with abundance decreasing of about 10 times since '90s in the Italian side (Figure 6.3.2.3.1). The pattern is slightly different in Croatian waters the early decline is also seen but where the indices show a modest increase since 2012 (Figure 6.3.2.3.2).

MEDITS indices of GSA 18 Italian side decrease in time even though two positive peaks were observed in 2009 and 2010 (Figure 6.3.2.3.3). Same 2009-2010 were observed in GSA18 Albanian side. General trend appears slightly decrease. Montenegro indices are shorter, moreover no surveys were carried out in 2009 and in 2017. General trend is decreasing.

Italy GSA 17



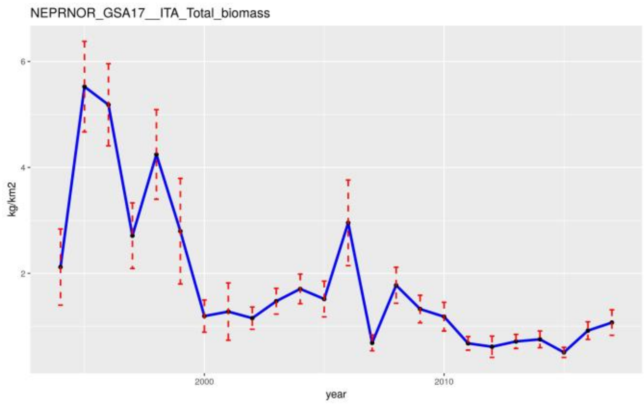
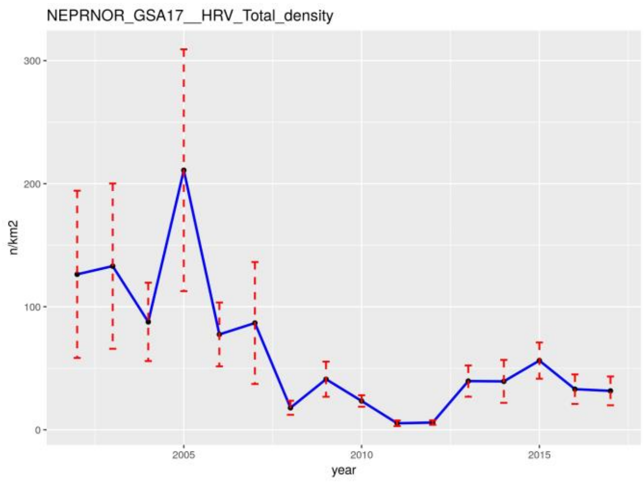


Figure 6.3.2.3.1 Norway lobster in GSA 17 and 18. Abundance (left) and biomass (right) indices from the MEDITS survey in the Croatian sides of GSA 17 during 1994 – 2017.

Croatia GSA 17



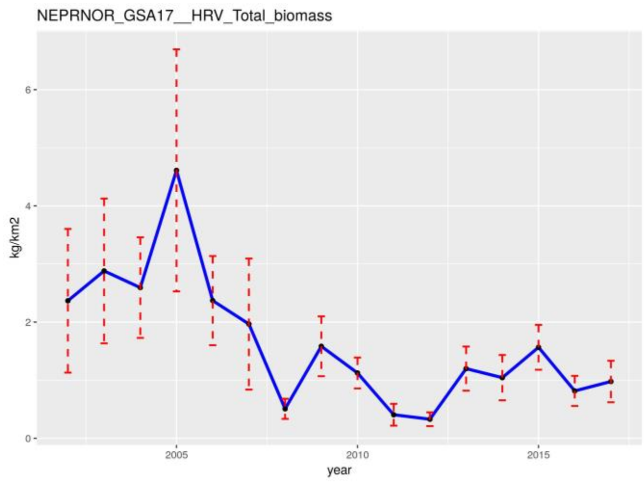


Figure 6.3.2.3.2 Norway lobster in GSA 17 and 18. Abundance (left) and biomass (right) indices from the MEDITS survey in the Croatian sides of GSA 17 during 2002 – 2017.

Italy GSA 18

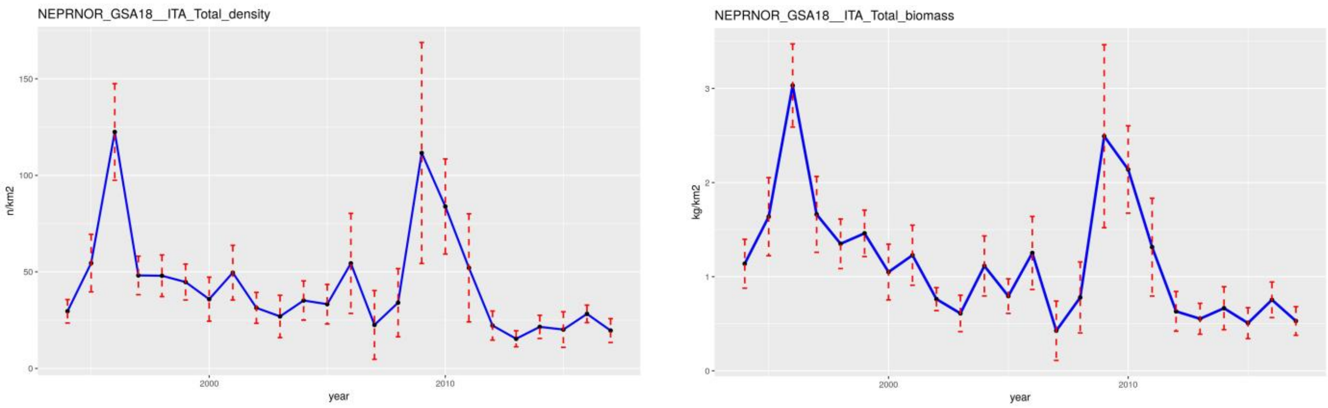


Figure 6.3.2.3.3 Norway lobster in GSA 17 and 18. Abundance (left) and biomass (right) indices from the MEDITS survey in GSA 18 Italian side in the period 1994 – 2017.

Albania GSA 18

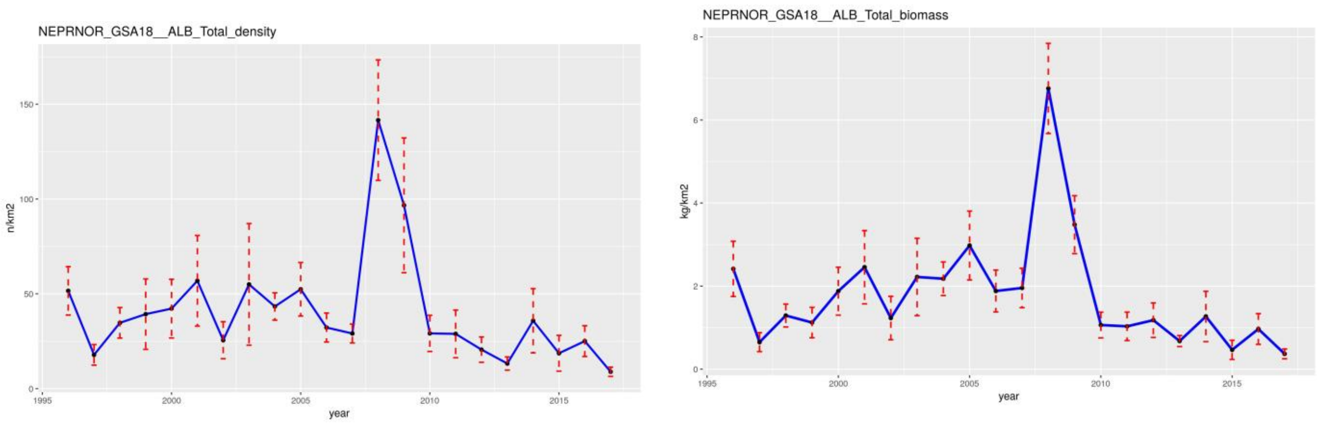


Figure 6.3.2.3.4 Norway lobster in GSA 17 and 18. Abundance (left) and biomass (right) indices from the MEDITS survey in GSA 18 Albanian side in the period 1996 – 2017.

Montenegro GSA 18

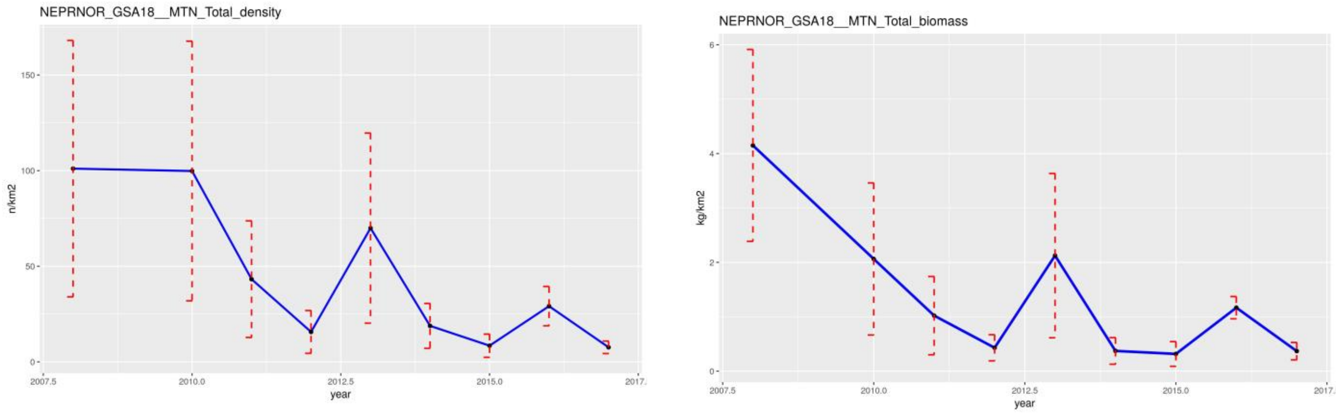


Figure 6.3.2.3.5 Norway lobster in GSA 17 and 18. Abundance (left) and biomass (right) indices from the MEDITS survey in GSA 18 Montenegro side in the period 2008 – 2016 (no survey in 2009 and 2017).

Length frequency distributions of the MEDITS surveys for sex combined are showed in Figures 6.3.2.3.6-10. In GSA 17 a recruitment peak appears in 2006 as observed in the catch data. Since then MEDITS did not register any abundant new year class and this can explain the observed decreasing trend.

Length frequency distributions of the MEDITS surveys for females, males and sex combined are showed in Figures 6.3.1.4.5 and 6.3.1.4.6. In GSA 17 a recruitment peak appears in 2006 as observed in the catch data.

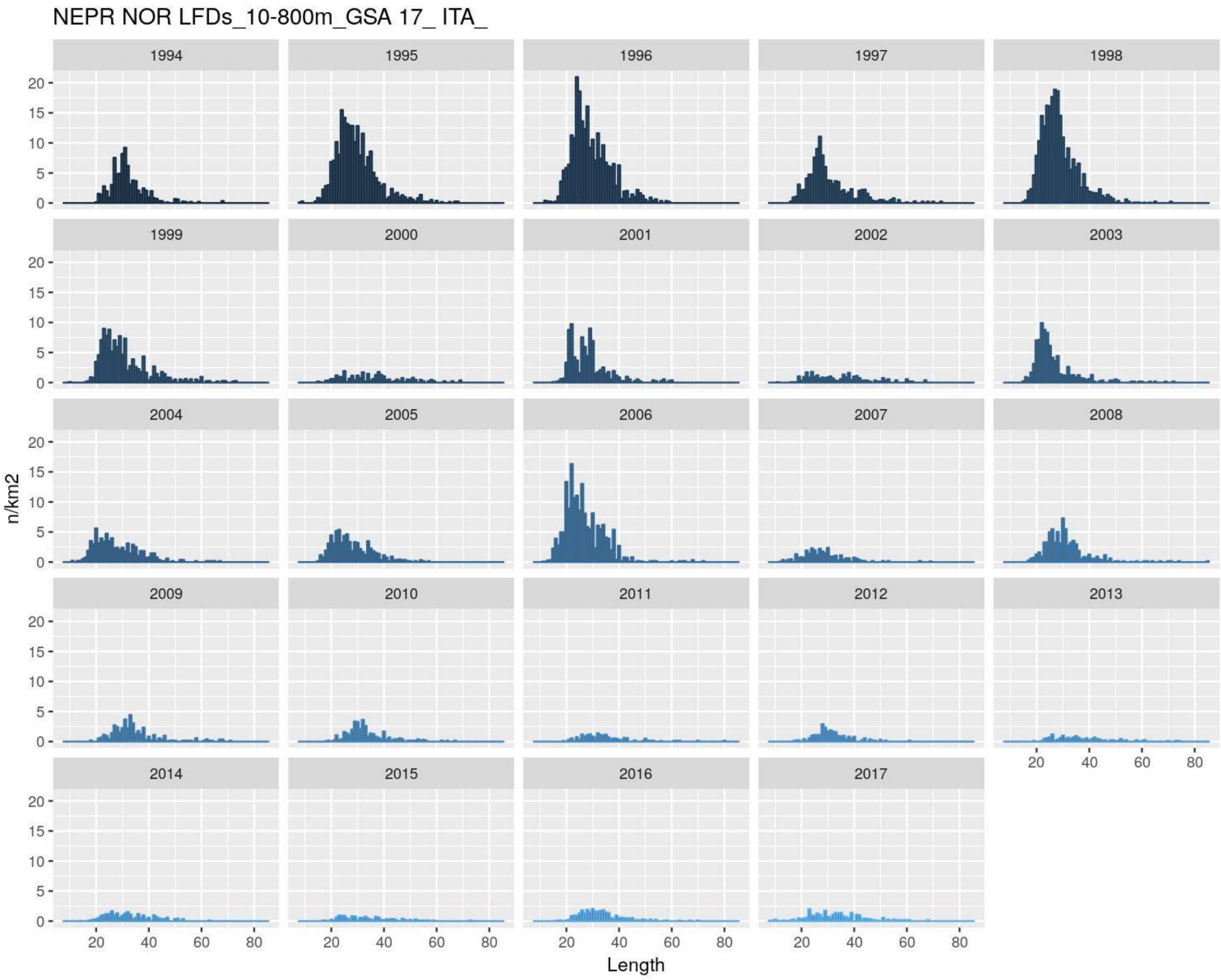


Figure 6.3.2.3.6. Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS Italy GSA17 survey in 1994-2017.

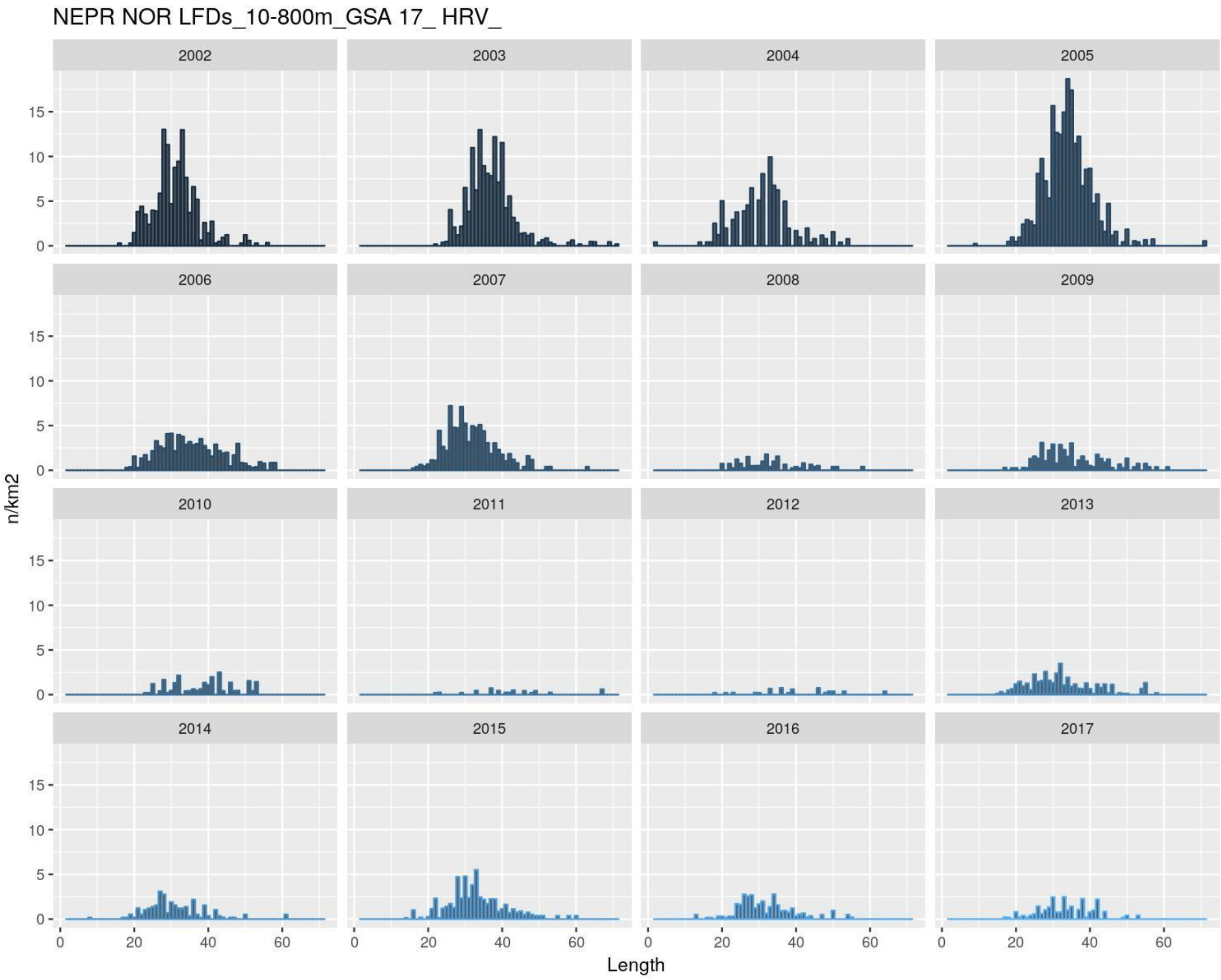


Figure 6.3.2.3.7 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS Croatia GSA17 survey in 2002-2017.

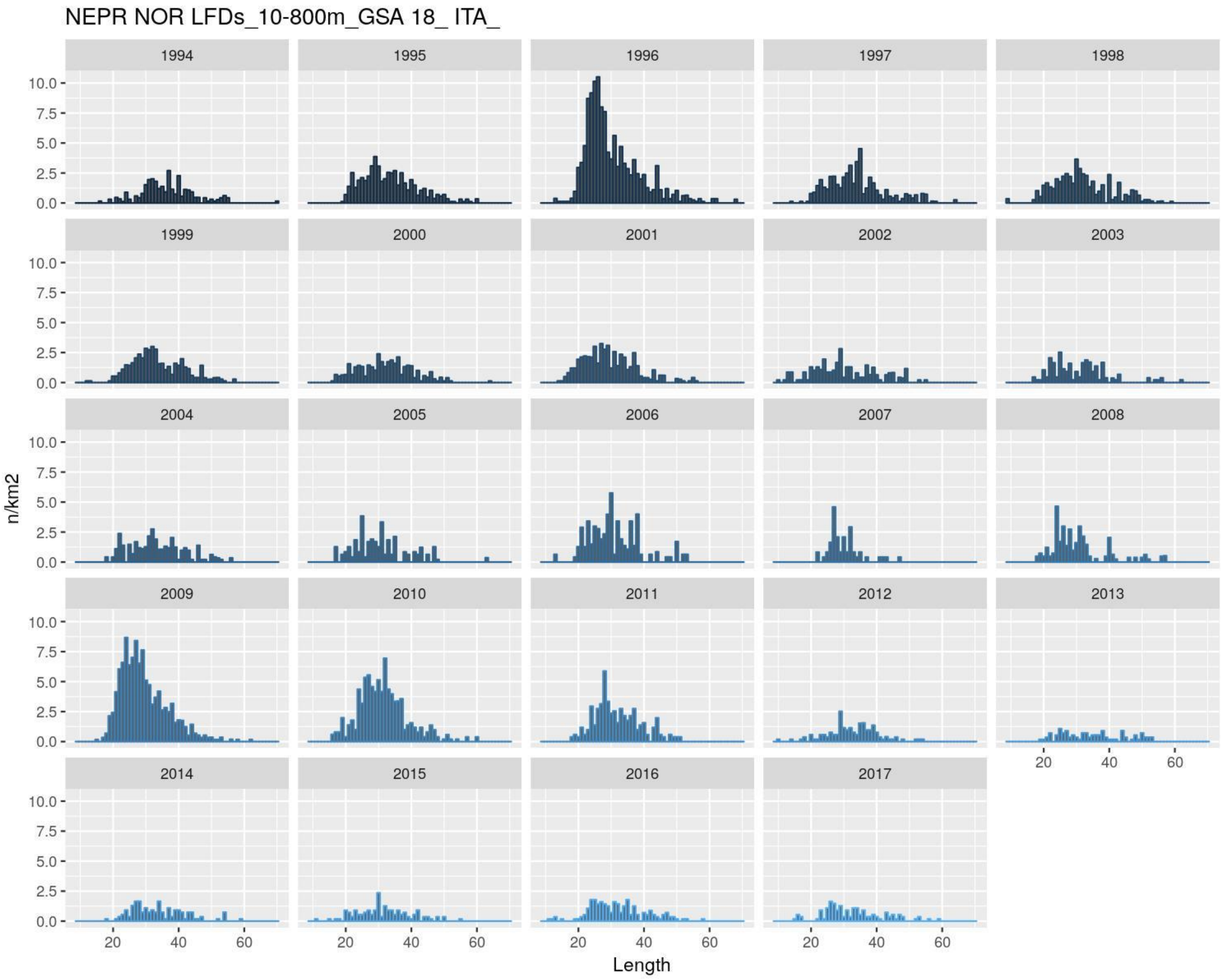


Figure 6.3.2.3.8 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS Italy GSA18 survey in 1994-2017.

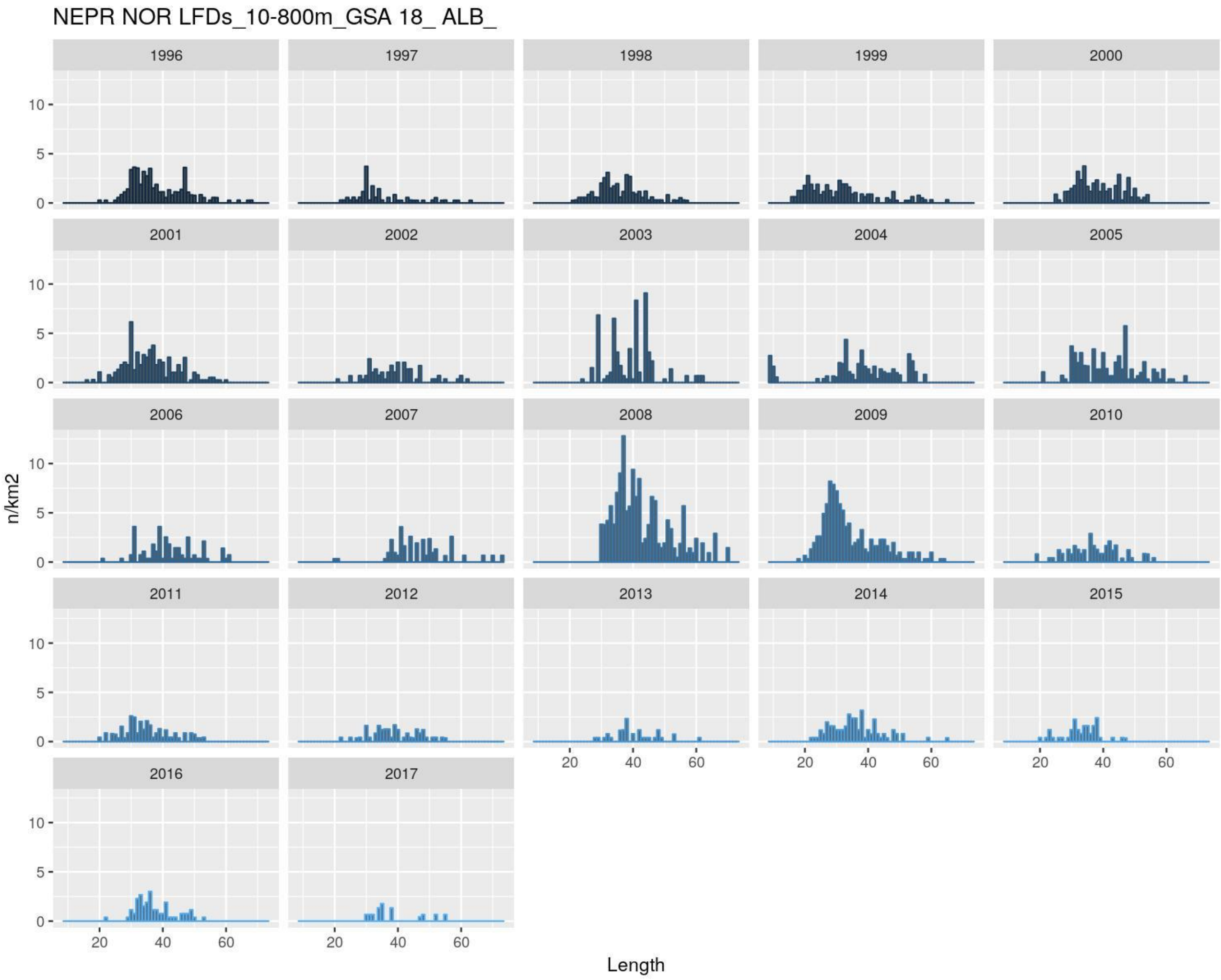


Figure 6.3.2.3.9 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS Albania GSA18 survey in 1996-2017.

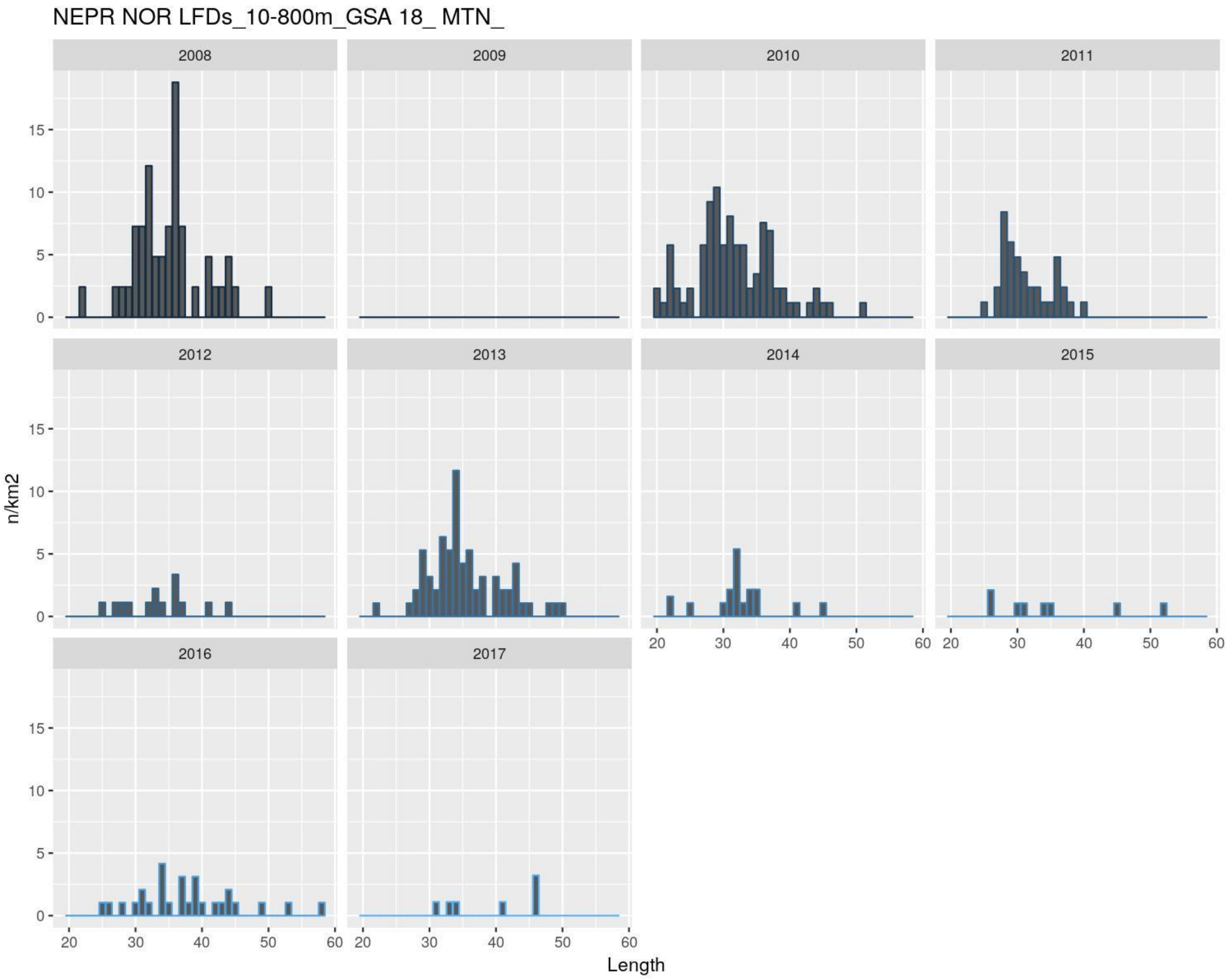


Figure 6.3.2.3.10 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS Montenegro GSA18 survey in 2008-2016 (in 2009 and 2017 the survey wasn't carried out).

Spatial distribution

According to MEDITS data the highest relative biomass (yellow bubble) occur in GSA17 around the Pomo Pit area while in GSA 18 the stock appears more abundant along both the east and west slope of the south sector of the GSA (Fig. 6.3.2.3.11).

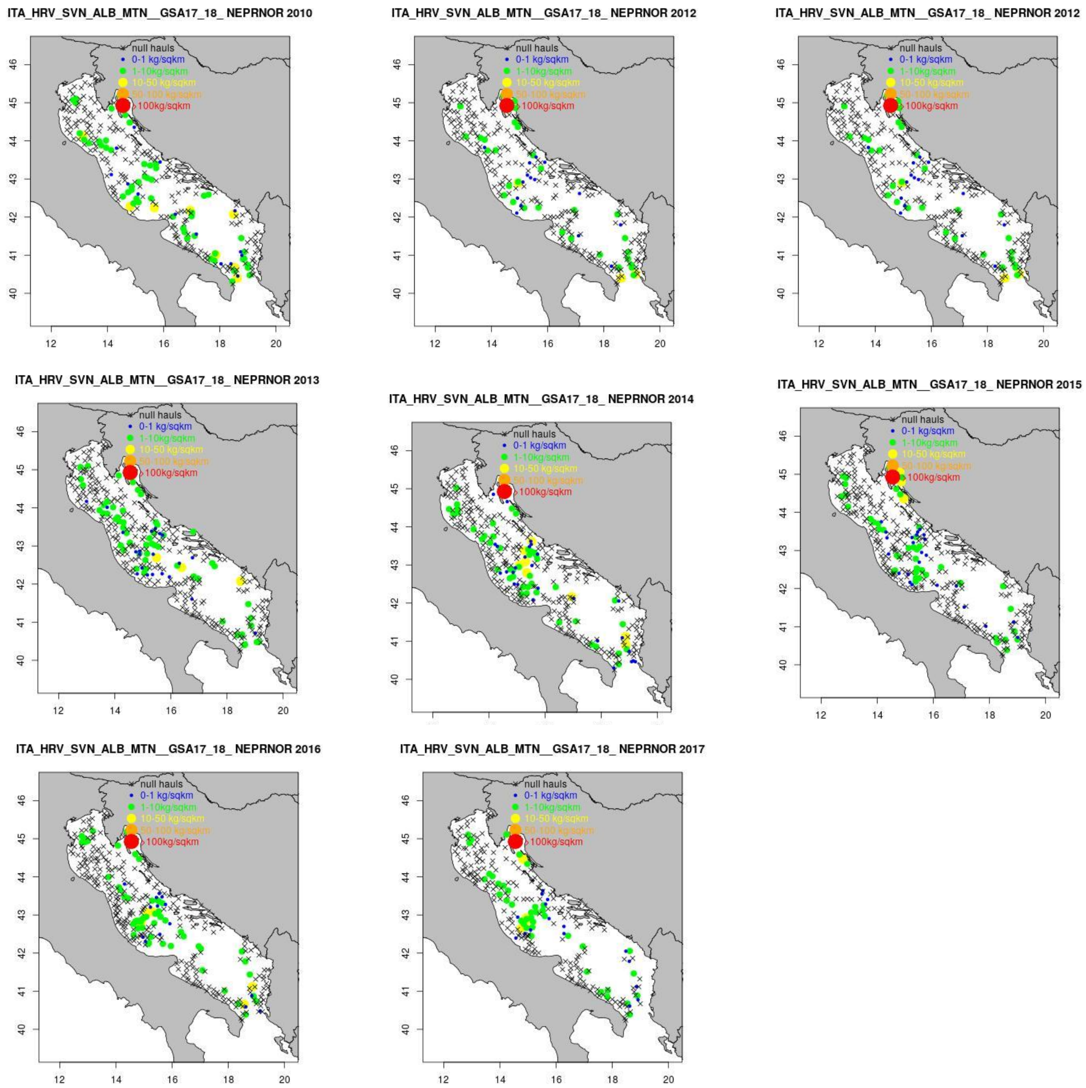


Fig. 6.3.2.3.11 Norway lobster in GSA 17 and 18. Spatial distribution of relative biomass (kg km^{-2}) during MEDITS from 2010 to 2017.

Figures 6.3.2.3.12-14 clearly show a different size distribution between the Norway lobster specimens distributed inside and outside the Pomo Pit with this latter displaying generally a peak of small specimens and the lack of adults over 50 mm CL.

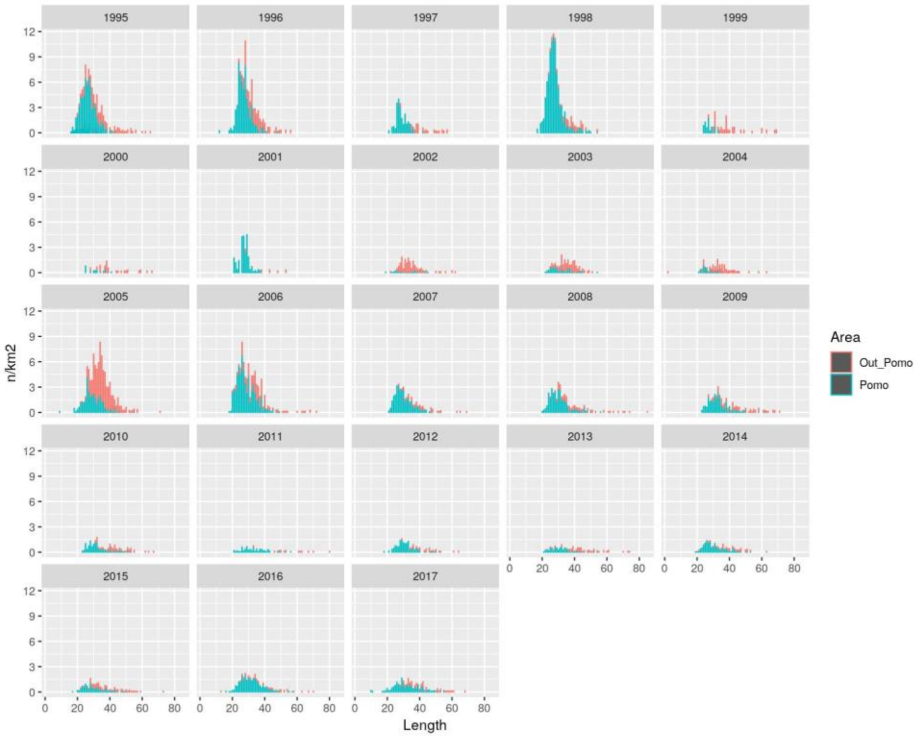


Figure 6.3.2.3.12 Norway lobster in GSA 17 and 18. MEDITS length frequency distributions (n km^{-2}) of specimens distributed inside and outside the Pomo Pit area.

Figure 6.3.2.3.13 Norway lobster in GSA 17 and 18. MEDITS length frequency distributions (n km^{-2}) of specimens distributed inside and outside the Pomo Pit area (Carapace Length >35mm)

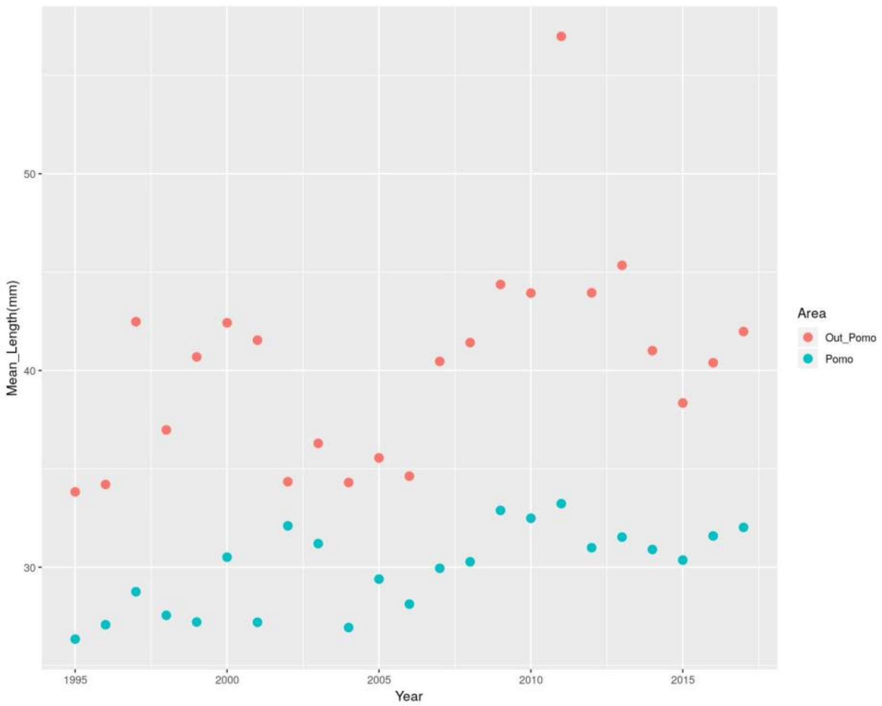


Figure 6.3.2.3.14 Norway lobster in GSA 17 and 18. MEDITS mean length of adult specimens distributed inside and outside the Pomo Pit area.

6.3.3 STOCK ASSESSMENT

The choice of stock assessment method to use for this stock was based on careful consideration of a number of issues. The different sources of sources of data and their short comings discussed above were considered together. The type of model was selected based on the following arguments: Ageing of Decapoda like *Nephrops norvegicus* is difficult and relies on indirect methods. With the specific uncertainties for this stock identified and explained in sections above on growth; the uncertainties on the proportion of the stock that lives in and outside Pomo, the potential mixing of landings between Nephrops from GSA 17 and 18 (STECF EWG 16-08), the EWG deemed that the best available combined GSA 17-18 as requested by the TORs. As STECF (PLEN 03) recommended the use of SPiCT, this was the model of choice for the surplus production assessment.

6.3.3.1 Method 1- Surplus Production model in Continuous Time - SPiCT

The Surplus Production in Continuous time (SPiCT) assessment method is briefly described here; Pedersen and Berg (2016) contains a comprehensive description of the model

The SPiCT assessment method is a state-space version of the Pella-Tomlinson surplus production model (Pella and Tomlinson 1969). The dynamics of fisheries (F_t) and exploitable biomass (B_t) are modelled as latent processes:

$$dB_t = rB_t\left(1-\left(\frac{B_t}{K}\right)^{n-1}\right)dt - F_tB_tdt + \sigma_B B_t dW_t$$

$$dlog(F_t) = f(t, \sigma_F)$$

Where W_t is Brownian motion and f represents a random walk process if yearly data are provided and a seasonal model for F if subannual data are available. The time series of catch and biomass index are used as observations with e_t and ϵ_t their corresponding error terms:

$$log(I_t) = log(qB_t) + e_t, e_t \sim N(0, [\alpha\sigma_B]^2)$$

$$log(C_t) = log\left(\int_t^{t+\Delta} F_s B_s ds\right) + \epsilon_t, \epsilon_t \sim N(0, [\beta\sigma_F]^2)$$

The following list summarises the model parameters:

- B_t: Exploitable biomass
- F_t: Fishing mortality
- r: Intrinsic growth rate (growth, recruitment, natural mortality)
- K: Carrying capacity
- n: Production curve shape parameter
- q: Catchability
- σ_B: Standard deviation of B_t
- σ_F: Standard deviation of F_t
- α: Ratio of standard deviation of I_t to σ_B
- β: Ratio of standard deviation of C_t to σ_F

SPiCT allows the inclusion of prior distributions for parameters that are difficult to estimate. By default, there are wide uninformative priors on n, α, and β; these can be removed.

The continuous time formulation of the model allows for arbitrary and irregular data sampling without a need for catch and index observations to match temporally.

Main assumptions

SPiCT shares many assumptions with other surplus production models:

1. No emigration/immigration, changes in biomass occur through growth (r and K) and fishing.
2. No lagged effects in the biomass dynamics
3. Constant catchability i.e. no change in technology of fishing technique that changes q.
4. Gear selectivity is not modelled
5. No knowledge of natural mortality is required

Data requirements - Expected outputs

SPiCT requires a time series of landings or catches and one or more time series of commercial or survey CPUE indices. The expected output include all parameter estimates and the most interesting derived quantities are the F/F_{msy} and B/B_{msy} that quantify the stock status. The results are presented using SPiCT's extensive plotting capabilities.

Forecasting and management

SPiCT is able to use the estimated underlying process model to make forecast of biomass, fishing mortality, catch and stock status (F/F_{msy} and B/B_{msy}). A forecasting period and a fishing scenario is set before fitting the model. The fishing scenario is a multiplication factor that is applied to the current fishing mortality.

Availability

SPiCT is available as an R (R Core Team 2015) package in the github online repository: https://github.com/mawp/spict. For fast and efficient estimation, SPiCT uses the Template Model Builder package (TMB, Kristensen et al., 2016).

INPUT Data

Because of this stock was already assessed using SPICT during EWG 17-15 data input used were the same of the previous assessment (STECF 17-15).

MEDITS time series was updated adding 2017 data.

LANDINGS data were updated according to revised Albania data and 2017 DCF landings.

Input data described in data section are reported below in the following R list. This forms the input data basis to run SPICT model on Nephrops GSA 17-18 combined

$obsC **(COMBINED LANDINGS GSA 17 + 18)**

1269.995 1283.481 1397.000 1113.000 1098.000 1197.000 1520.000 2104.000 1469.000 1288.000
1116.000 1185.000 1407.000 1270.000 1219.000 2109.000 2350.000 2087.000 2836.000 2159.000 1890.000 2507.000 3151.000 3122.000 3366.000 3148.000 3558.000 3058.000 2426.000 1753.000 1864.000 1558.737 1252.473 2218.550 2279.430 3393.676 3107.017 2775.057 2654.241 2799.682 2523.373 1955.759 1955.231 2116.542 1715.697 1596.447 1398.011 1430.547

$timeC **(COMBINED LANDINGS GSA 17 + 18)**

1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

$timeI[[1]] **(from Froglia 1988)**

1976 1977 1978 1979 1980 1981 1982 1983 1984 1985

$timeI[[2]] **(from Jukic 1975)**

1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970

$timeI[[3]] **(MEDITS)**

1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

$obsI[[1]] **(from Froglia 1988)**

5.044500 7.740429 2.766750 1.551000 1.621000 2.169400 1.867563 1.449312 3.866662 3.348465

$obsI[[2]] **(from Jukic 1975)**

68.64132 46.32997 25.28125 16.38208 25.47517 43.61067 67.90581 72.84041 95.12000 56.87619 45.43182

$obsI[[3]] **(MEDITS)**

1.9158145 4.6384583 4.4088801 2.3838589 3.5990604 2.4670327 1.2525669 1.4142344 1.2396781 1.6297531 1.8097623 2.2438285 2.2445496 0.9567454 1.8189362 1.8958613 1.3055689 0.7713658 0.5772342 0.8351308 0.8274397 0.7034755 0.8705598 0.8521402

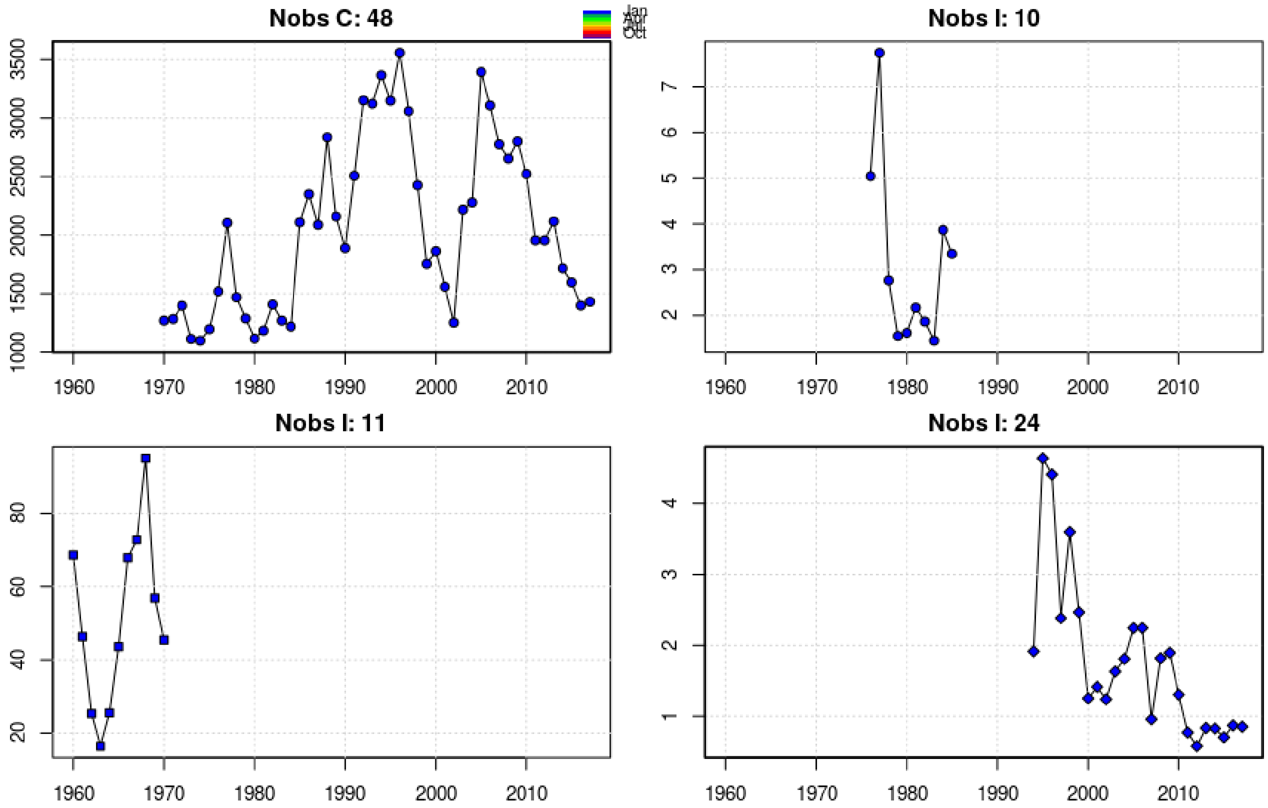


Figure 6.3.3.1.1 Norway lobster in GSA 17 and 18. Input Data from Norway lobster GSA 17-18. Index 1 = Froglia, Index 2 = Jukic, Index 3 = MEDITS.

SPiCT was run with the default prior settings and no informative priors for initial parameter estimates. The model converged and the diagnostic results (Residuals, Auto correlation and Shapiro p-values) are good for both catches and the 3 tuning indexes (Figures 6.3.3.1.2-3).

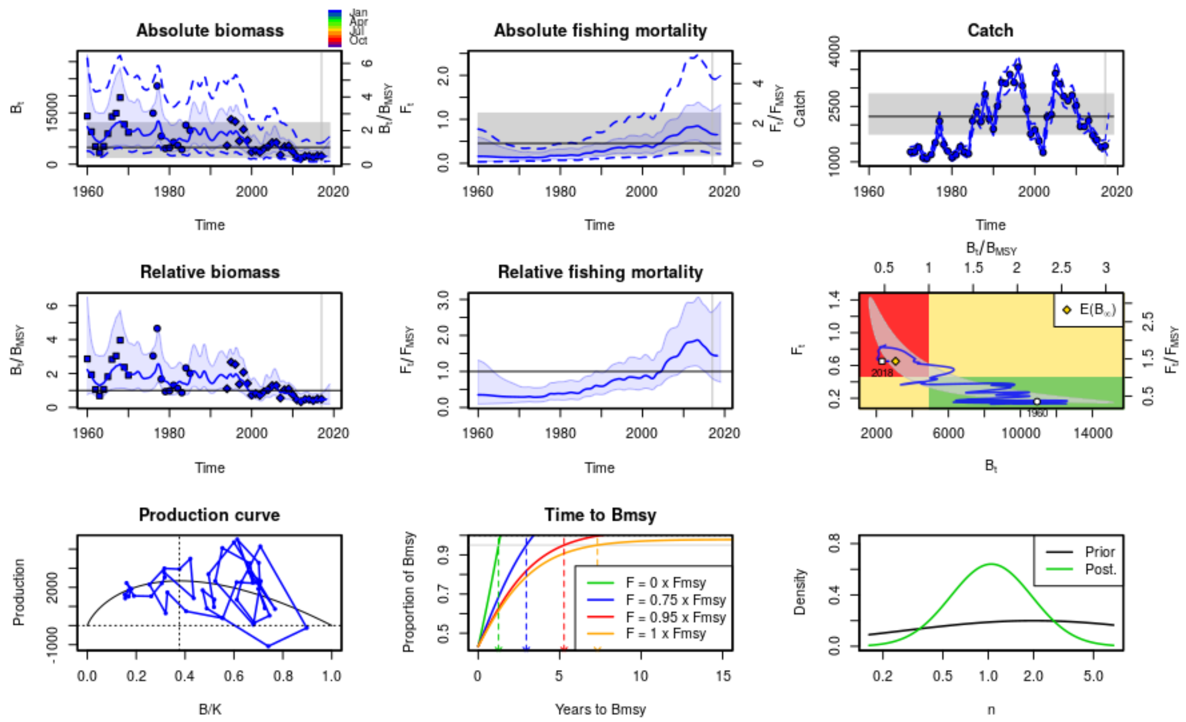


Figure 6.3.3.1.2 Norway lobster in GSA 17 and 18. SPiCT model fit with full time series and 3 CPUE indexes.

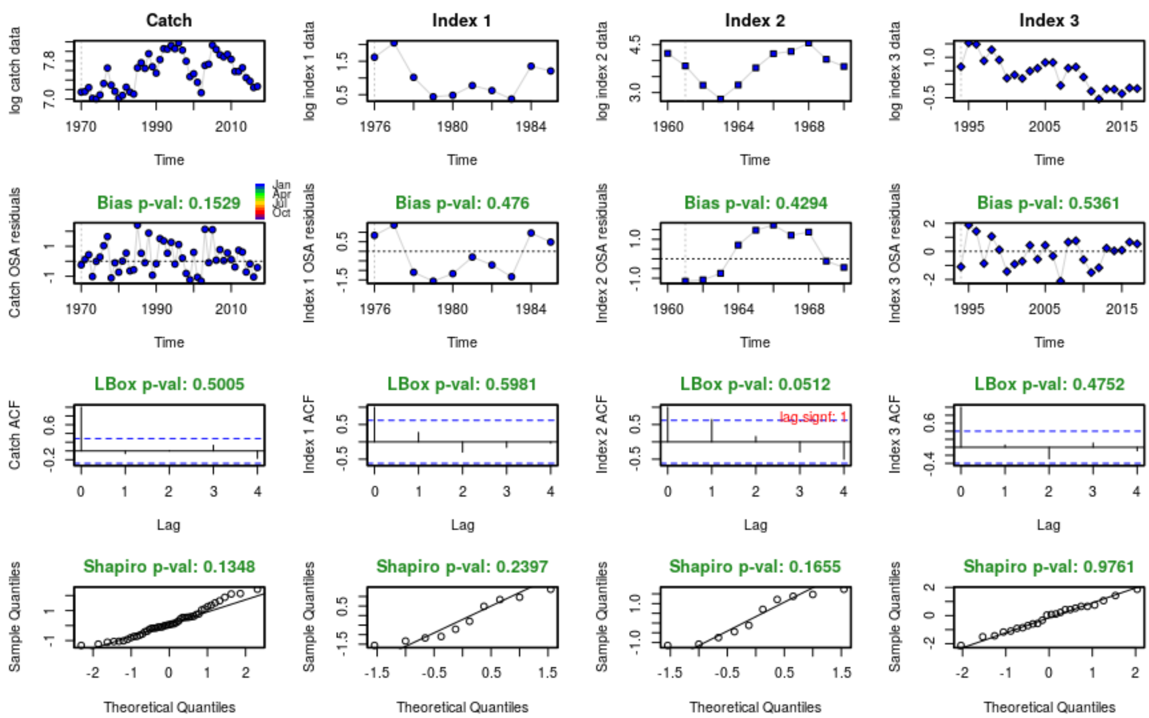


Figure 6.3.3.1.3 Norway lobster in GSA 17 and 18. Diagnostics for SPICT model of Norway lobster GSA 17-18. Index 1 = Froglia, Index 2 = Jukic, Index 3 = MEDITS.

A retrospective was run with 4 retro years. For production models, the most reliable estimates are in terms of F/Fmsy and B/Bmsy. The retrospective patterns are very consistent across years in terms of B/Bmsy with biomass estimated well below Bmsy. There is have a tendency to higher F in the run without the last 4 years (blue line), this is driven by the MEDITS index that is showing an increase in the last 3 years so the pattern comes from the data and not a fitting issue. F/Fmsy is estimated to be greater than 1 in all runs for all years after 2005. The coherence of the results indicates the retrospective performance is acceptable (Figure 6.3.3.1.4).

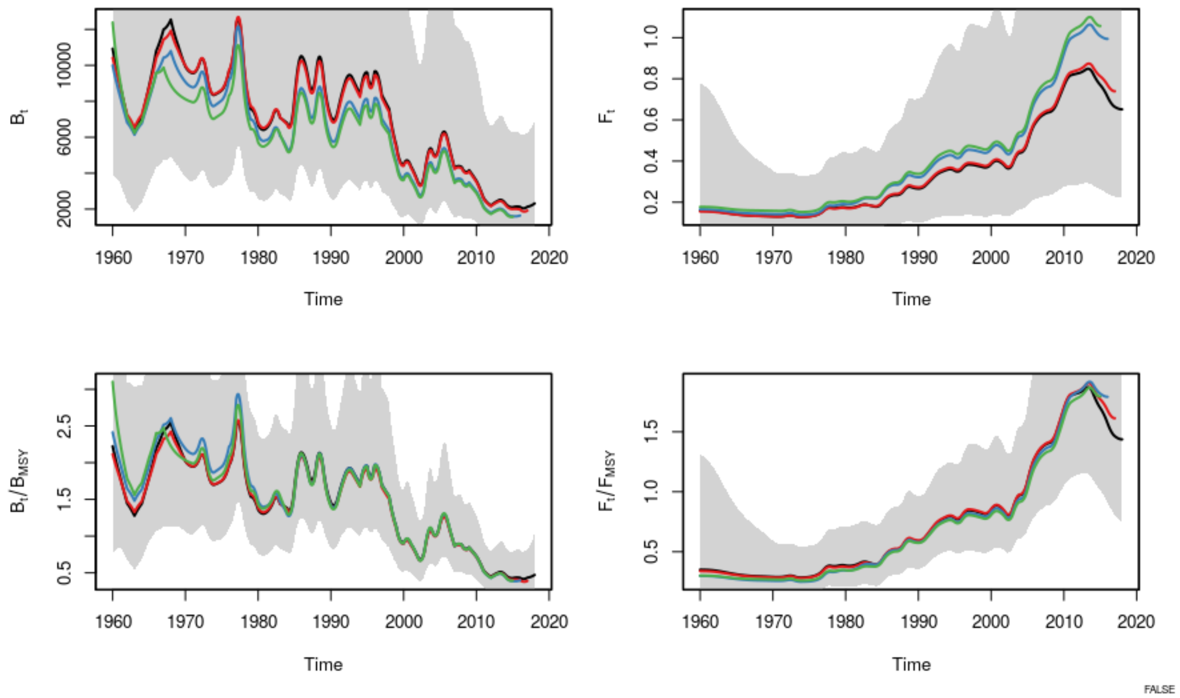


Figure 6.3.3.1.4 Norway lobster in GSA 17 and 18. Retrospective analysis for Norway lobster in GSA 17-18.

Model estimates, reference points and summaries are reported below:

Convergence: 0 MSG: relative convergence (4)
Objective function at optimum: 31.1024606
Euler time step (years): 1/16 or 0.0625
Nobs C: 48, Nobs I1: 10, Nobs I2: 11, Nobs I3: 24

Priors
    logn ~ dnorm[log(2), 2^2]
 logalpha ~ dnorm[log(1), 2^2]
  logbeta ~ dnorm[log(1), 2^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha1	1.740148e+00	0.8259573	3.666189e+00	0.5539703
alpha2	1.433558e+00	0.3708547	5.541492e+00	0.3601595
alpha3	1.031732e+00	0.5043306	2.110659e+00	0.0312385
beta	3.751305e-01	0.0664825	2.116691e+00	-0.9804813
r	**4.756618e-01**	**0.1280900**	**1.766369e+00**	**-0.7430482**
rc	9.082025e-01	0.3659214	2.254123e+00	-0.0962879
rold	1.001824e+01	0.0000000	1.910674e+12	2.3044071
m	2.337686e+03	1778.8827961	3.072027e+03	7.7569168
K	**1.367518e+04**	**5960.9673386**	**3.137251e+04**	**9.5233377**

```
q1     3.382000e-04    0.0001348 8.487000e-04 -7.9918622
q2     4.882000e-03    0.0019842 1.201190e-02 -5.3221942
q3     3.537000e-04    0.0001295 9.658000e-04 -7.9470976
n      1.047480e+00    0.3089532 3.551390e+00  0.0463869
sdb    2.505531e-01    0.1466741 4.280022e-01 -1.3840846
sdf    1.388983e-01    0.0788616 2.446402e-01 -1.9740134
sdi1   4.359995e-01    0.2618738 7.259052e-01 -0.8301143
sdi2   3.591823e-01    0.1344702 9.594094e-01 -1.0239251
sdi3   2.585035e-01    0.1744371 3.830841e-01 -1.3528461
sdc    5.210500e-02    0.0110072 2.466506e-01 -2.9544947

Deterministic reference points (Drp)
          estimate        cilow        ciupp    log.est
 Bmsyd 5147.9397414 2074.5091530 12774.724828  8.5463519
 Fmsyd    0.4541013    0.1829607     1.127061 -0.7894351
 MSYd  2337.6859353 1778.8827961  3072.026748  7.7569168

Stochastic reference points (Srp)
          estimate        cilow       ciupp    log.est rel.diff.Drp
 Bmsys 4914.5486083 1993.0459808 12118.53026  8.4999552 -0.047489841
 Fmsys    0.4534204    0.1804356     1.13941 -0.7909355 -0.001501614
 MSYs  2228.1977122 1750.3955721  2836.42459  7.7089483 -0.049137571

States w 95% CI (inp$msytype: s)
                  estimate       cilow        ciupp    log.est
 B_2017.00      2128.9715533 727.2506413 6232.4040950  7.6633943
 F_2017.00         0.6633962   0.2275686    1.9338985 -0.4103829
 B_2017.00/Bmsy    0.4331978   0.2281204    0.8226372 -0.8365609
 F_2017.00/Fmsy    1.4630929   0.8050063    2.6591604  0.3805526

Predictions w 95% CI (inp$msytype: s)
                prediction        cilow       ciupp    log.est
 B_2018.00      2313.4991832  771.9763142 6933.215919  7.7465165
 F_2018.00         0.6515134    0.2205063    1.924978 -0.4284573
 B_2018.00/Bmsy    0.4707450    0.2122496    1.044058 -0.7534387
 F_2018.00/Fmsy    1.4368860    0.7428162    2.779478  0.3624783
 Catch_2018.00  1589.7522761 1054.5148560 2396.658791  7.3713335
 E(B_inf)       3065.4112819           NA          NA  8.0279370
```

6.3.2 Method 2- Statistical Catch at age – a4a

General assumptions:

Nevertheless, well known issues (different growth rate between Pomo and outside Pomo pit resulting in different sub-population) in running a fully analytical model on this stock during EWG18-16 an attempt was done based on two main scenarios for GSA17: i) the whole stock in GSA17 growth according to VBGF parameters in Pomo and ii) the whole stock in GSA17 growth according to VBGF parameters outside Pomo.

Moreover, final stock object was built up working by separated sex.

Finally, the following assumptions were made:

1) All data used were from DataCall2018 except HRV Landings before 2013 which were extracted from FAO (GFCM) FishStatJ database online.

2) 2006-2012 Croatia LFDs were reconstructed as mean of the available LFDs (2013-2017) according to landing in weight of each year.

3) LFD ITA18 2006 reconstructed as mean of 2005 and 2007 LFDs

4) Because data for ITA GSA17 were available only from 2006 onward to avoid further data manipulation stock object was built according to this period (2006-2017).

5) Within the same GSA natural mortality, mean weight and maturity slots were compiled as weighted mean by sex abundance (e.g. natural mortality vector <- natural mortality vector of male*total male catches+ natural mortality vector of female*total female catches/(total female catches + total male catches)

6) For different GSAs natural mortality, mean weight and maturity slots were compiled as weighted mean by catch abundance (e.g. natural mortality vector <- natural mortality vector of GSA17*total catches GSA17+ natural mortality vector of GSA18 * total catches GSA18/(total catches GSA17+ total catches GSA18)

7) MEDITS index was compute for 17 and 18 separately and then combined according to a weighted mean by GSA surface (e.g. index <- index of GSA17*total area GSA17+ index of GSA18 * total area GSA18/(total area GSA17+ total area GSA18)

8) LFD from commercial catches were splitted by sex according to a sex ratio vector obtained by modeling available sex ratio vectors by length in the areas (Figure 6.3.3.1.5 GSA18 model)

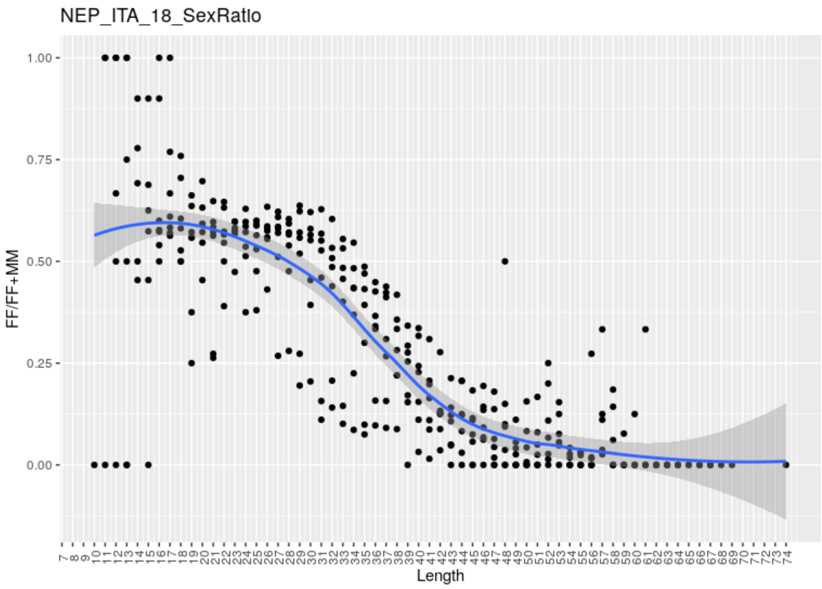


Figure 6.3.3.2.1 Norway lobster in GSA 17 and 18. Sex ratio model applied in splitting commercial length frequency distribution by sex in GSA18

9) Length distribution by sex were converted in age using l2a function available in a4a package (6 was considered as maximum age; plus group)

10) All available data in both in term of weight and abundance by landings and discards were used. Nevertheless, discards could be considered negligible all data available were used in the analysis.

11) Natural mortality vectors were computed according to Chen Watanabe formula:

ChenWatanabe=k/(1-(exp(-k*AGE_Y-t0)))) Y=sequence of age from 0.5 to 6.5

12) Maturity and mean weight vectors were estimated as reported in section 6.3.1.

13) June/July period was considered as spawning season (accordingly proportion of natural and fishing mortality before spawning were settled as 0.5)

POMO

Input data

As index was used a combined MEDITS survey. Length distribution by sex were converted in age by l2a tool (a4a package). Finally, a combined index was obtained weighting each GSA index by the area (see previous explanations).

Index

year

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	6.259105	1.024943	0.147264	0.053356	0.094961	0.010000	0.228216	0.277420	0.163670	0.404680
1	58.514951	19.382430	19.225395	16.012430	8.601143	4.546291	5.711592	6.277752	8.985722	7.502486
2	29.377462	12.358089	18.238047	23.355586	14.693069	7.994383	6.539260	6.915739	7.747276	7.800981
3	13.157452	4.659885	7.167672	10.792908	8.033318	5.569202	3.544852	4.308706	4.600654	4.807322
4	4.059876	1.208879	5.031378	3.807656	3.940196	1.700290	1.938907	2.068101	1.977434	1.297157
5	2.859502	1.596642	2.336936	1.849329	1.084672	0.691775	0.581714	1.205483	0.752100	0.646688
6	3.493896	1.685140	5.331529	4.161671	2.795020	1.499237	1.087734	2.375011	1.592423	2.059028

year

age	2016	2017
0	0.382765	0.703073
1	9.274856	6.825967
2	11.462493	7.861459
3	5.189469	4.502839
4	2.057555	1.585539
5	0.906707	0.502217
6	1.373246	2.037928

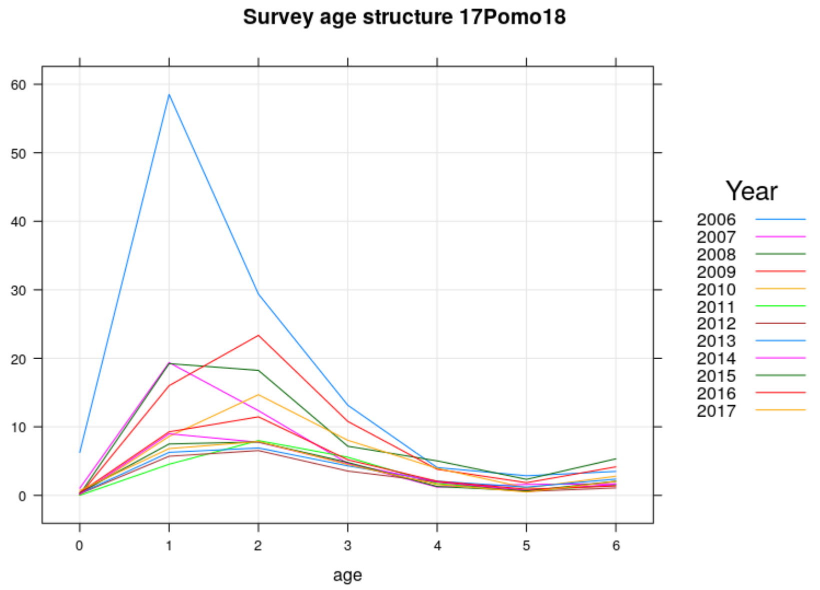


Figure 6.3.3.2.2 Norway lobster in GSA 17 and 18. MEDITS age composition in GSA17 (Pomo) and 18.

Catch in number were derived combining sliced (l2a) commercial length distribution by sex according to a weighting mean by sex (same GSA) and abundance (different GSAs). At the end of the process any SOP correction was needed.

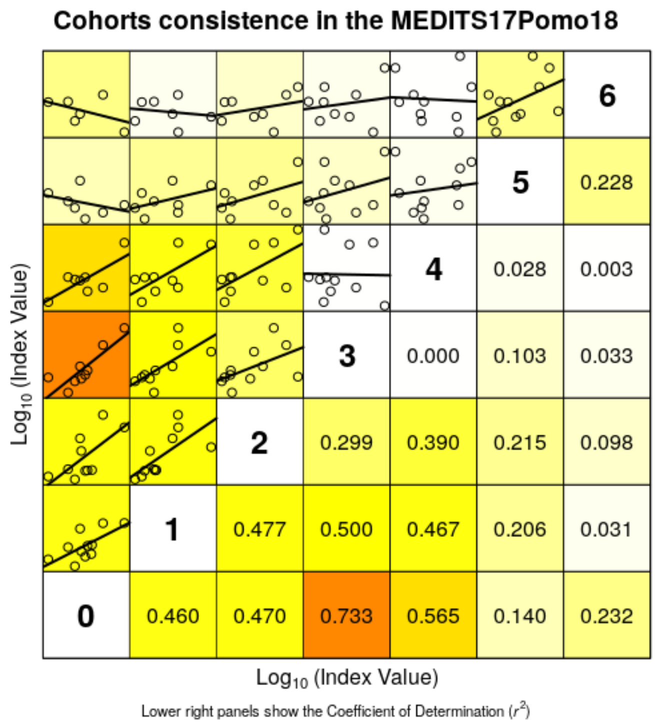


Figure 6.3.3.2.3 Norway lobster in GSA 17 and 18. Cohort consistency in MEDITS age matrix in GSA17 (Pomo) and 18.

Catch in number

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	2619.099	247.536	28.132	421.613	114.376	2011.879	277.170	513.059	514.729	235.802
1	91244.761	56451.429	16240.722	25220.640	47832.911	51021.251	31923.186	18711.034	24503.216	9202.959
2	41627.193	53495.048	53381.250	51487.103	35702.455	28400.543	29196.840	25967.502	25765.997	17129.959
3	18373.357	19799.968	19464.960	17627.719	15281.681	10682.744	11730.343	16743.187	10201.131	11643.569
4	5593.846	4327.028	3600.965	4144.743	4448.322	3132.759	4120.534	5753.020	3318.597	4997.611
5	2208.193	2045.614	1339.311	1767.181	1812.191	1046.659	1567.067	1994.391	1293.813	1590.482
6	1403.742	1398.607	1773.324	3272.572	2292.481	1198.075	2060.400	2701.053	3078.331	2221.750

age	2016	2017
0	39.882	424.264
1	3772.082	9700.138
2	13370.795	15453.998
3	11637.844	11935.161
4	4333.535	4536.151
5	1718.190	1393.241
6	2026.395	2074.102

units: 1000

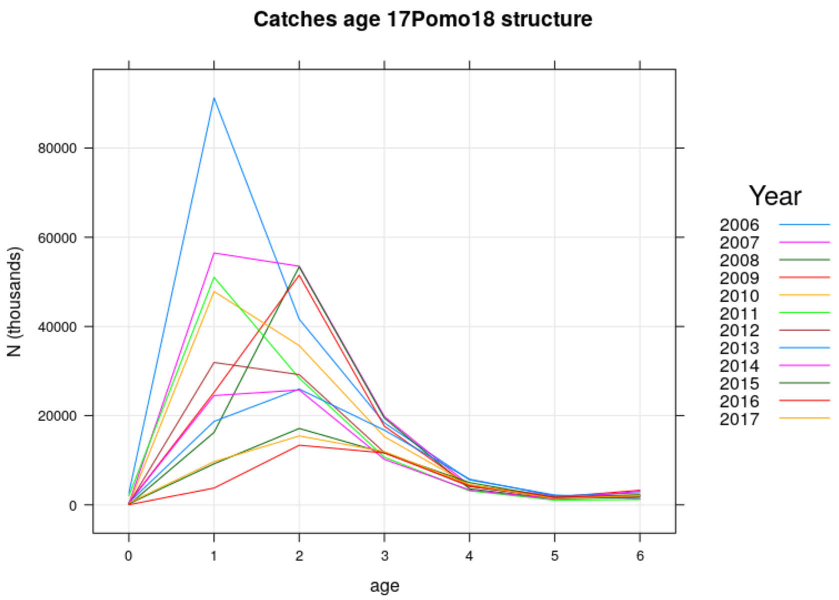


Figure 6.3.3.2.4 Norway lobster in GSA 17 and 18. Catch age composition in GSA17 (Pomo) and 18.

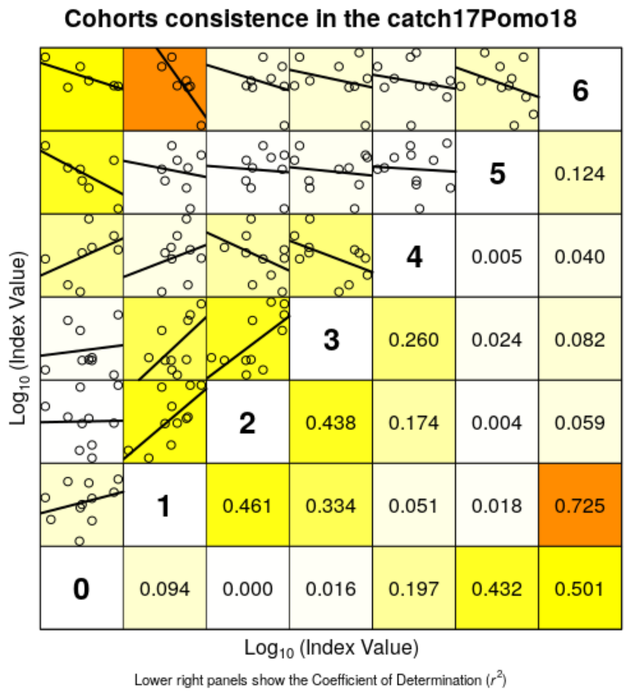


Figure 6.3.3.2.5 Norway lobster in GSA 17 and 18. Cohort consistency in catch age matrix in GSA17 (Pomo) and 18.

All the other input data are reported in the previous sections (6.3.1 and 6.3.2). In Figure 6.3.3.2.3 the final input data are showed.

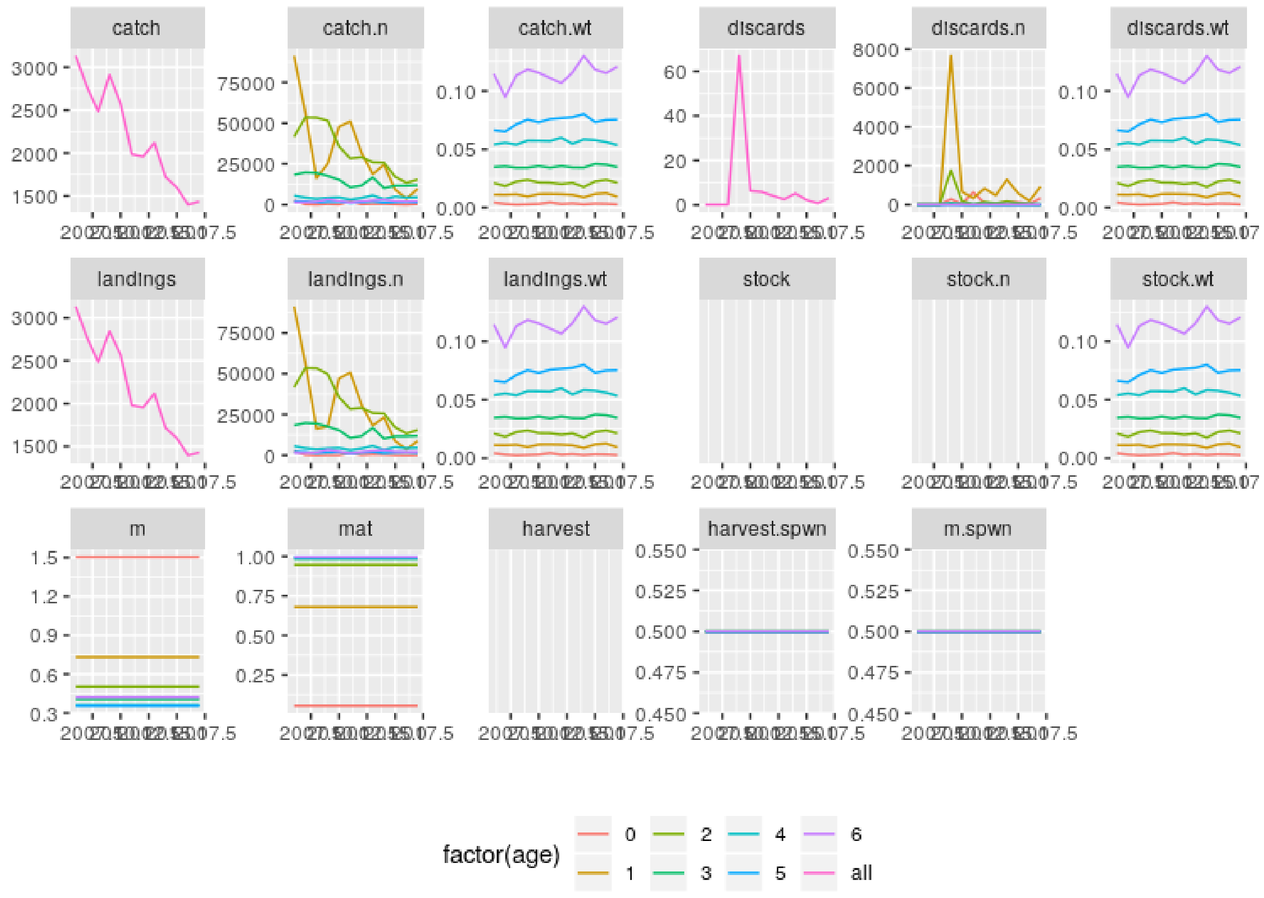


Figure 6.3.3.2.6 Norway lobster in GSA 17 and 18. a4a Input data in GSA17 (Pomo) and 18.

MODEL SETTING AND DIAGNOSTIC

According to the diagnostic the best model choose was:

fmodel <- ~ factor(age)+s(year, k=6)

qmodel<- list(~ factor(replace(age,age>2,2)))

vmodel <- list(~1,~s(age, k = 3))

srmodel<- ~factor(year)
n1model<- ~s(age, k = 4)

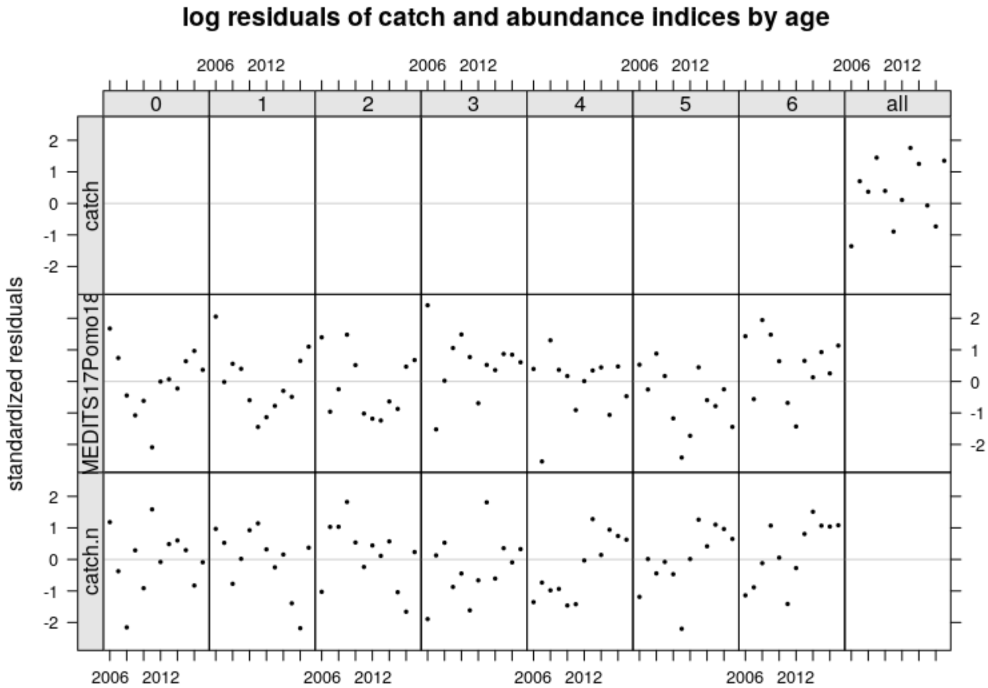


Figure 6.3.3.2.7 Norway lobster in GSA 17 and 18. Model residuals in GSA17 (Pomo) and 18.

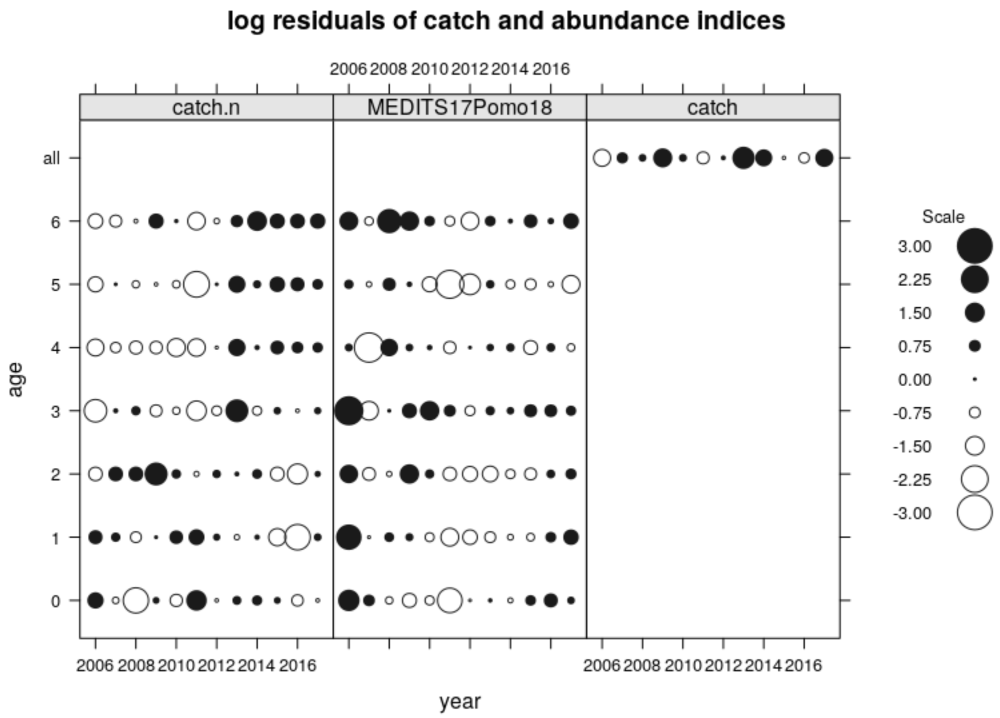
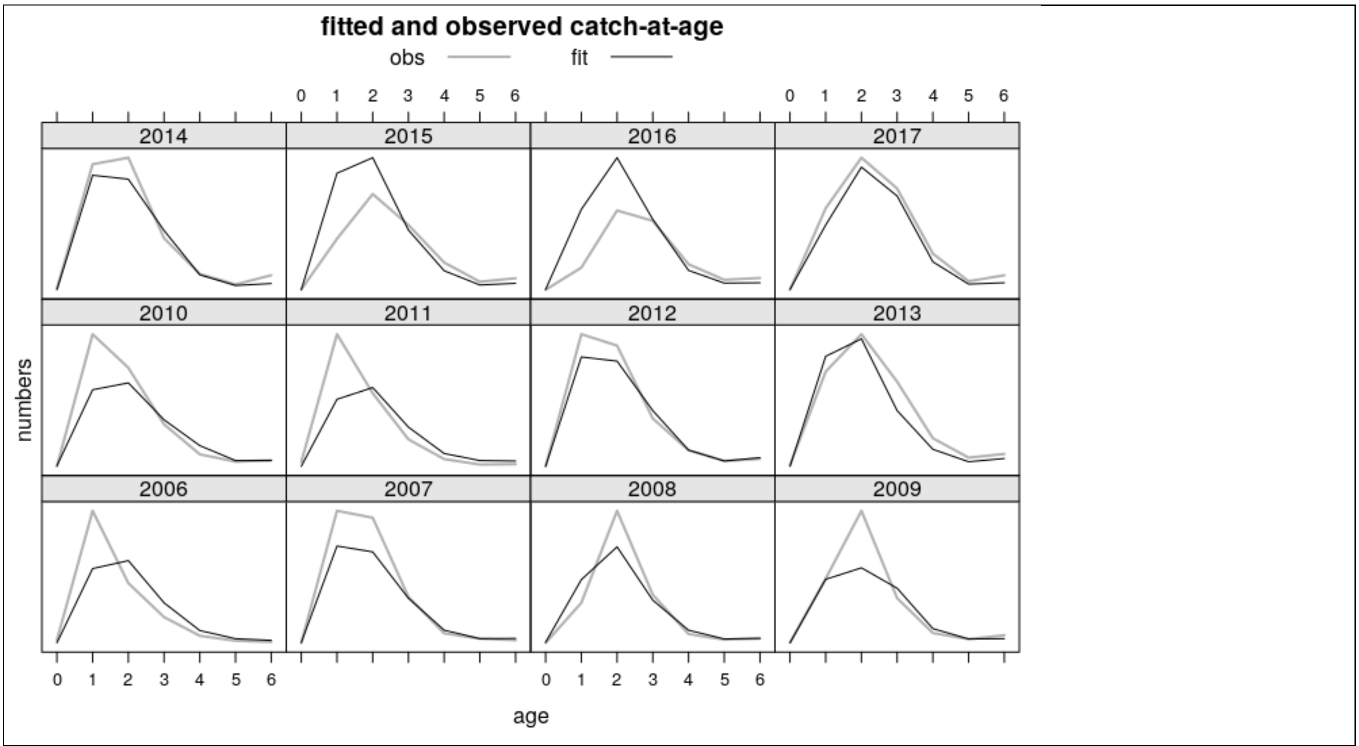


Figure 6.3.3.2.8 Norway lobster in GSA 17 and 18. Bubble plot of model residuals in GSA17 (Pomo) and 18



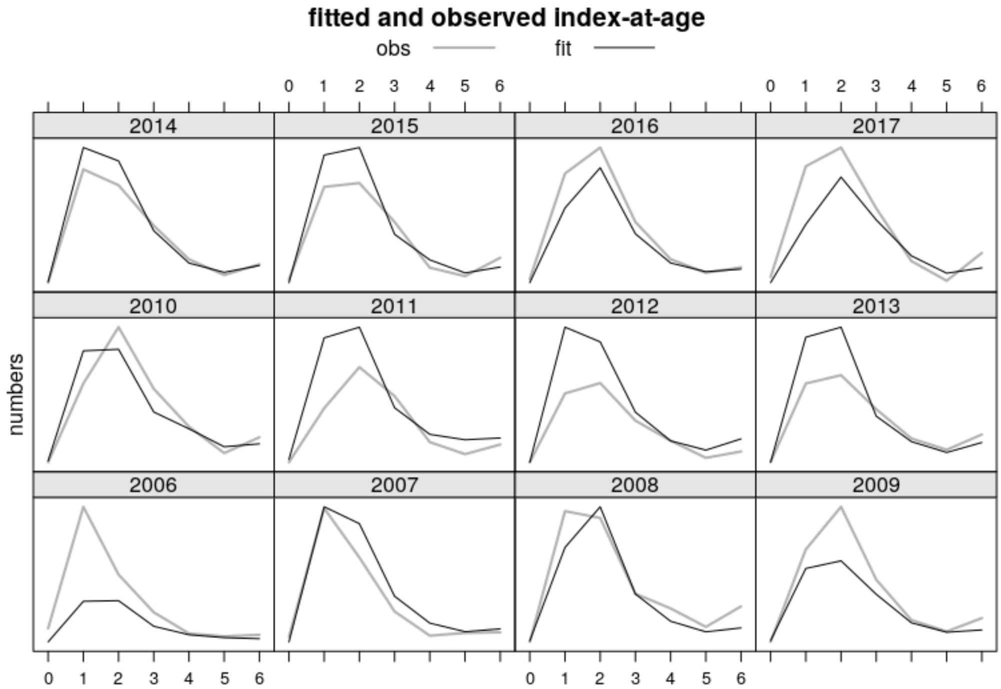


Figure 6.3.3.2.9 Norway lobster in GSA 17 and 18. Model fit in GSA17 (Pomo) and 18. Upper panel catch fit and lower panel index fit.

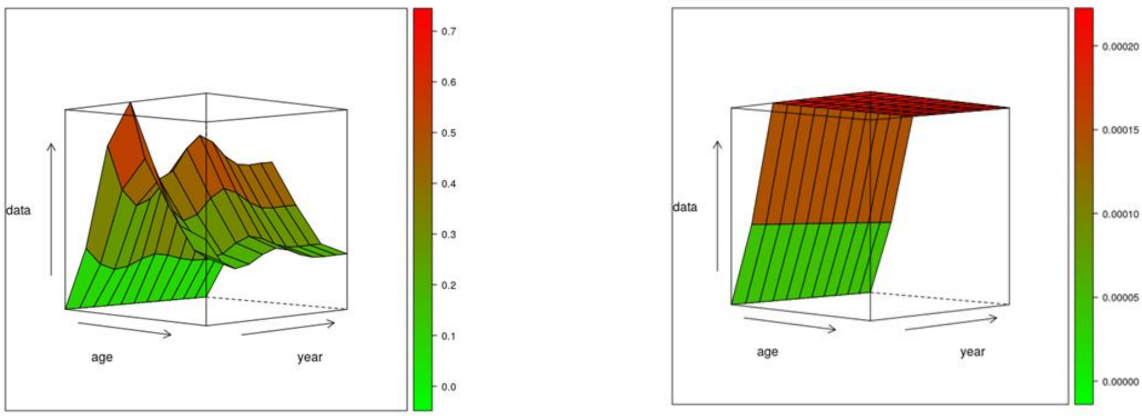


Figure 6.3.3.2.10 Norway lobster in GSA 17 and 18. Model fit in GSA17 (Pomo) and 18. left panel exploitation pattern and right panel catchability.

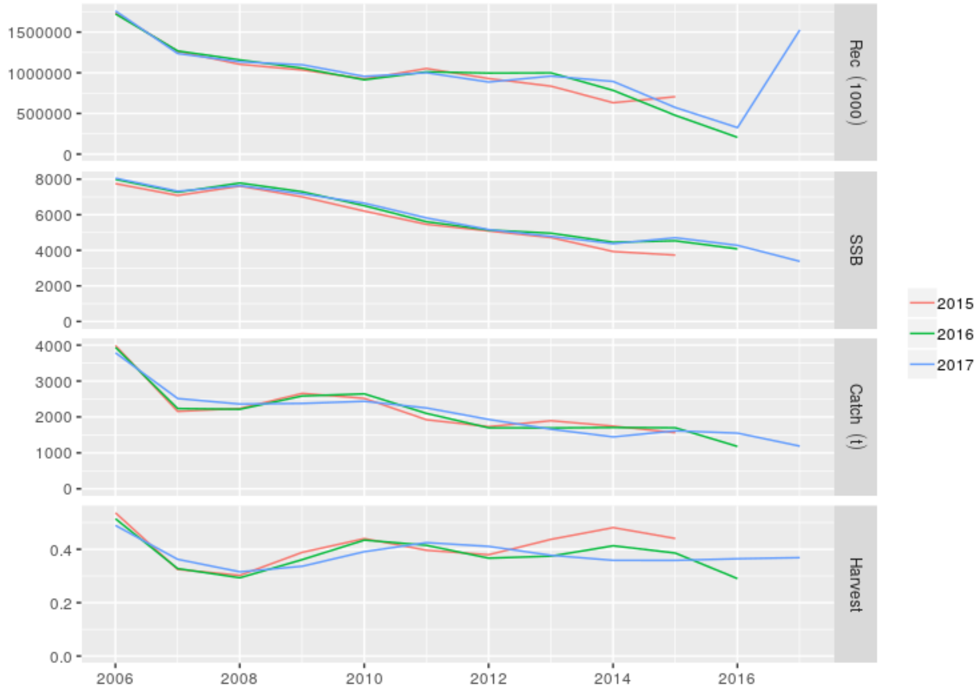


Figure 6.3.3.2.11 Norway lobster in GSA 17 and 18. Model retrospective analysis in GSA17 (Pomo) and 18.

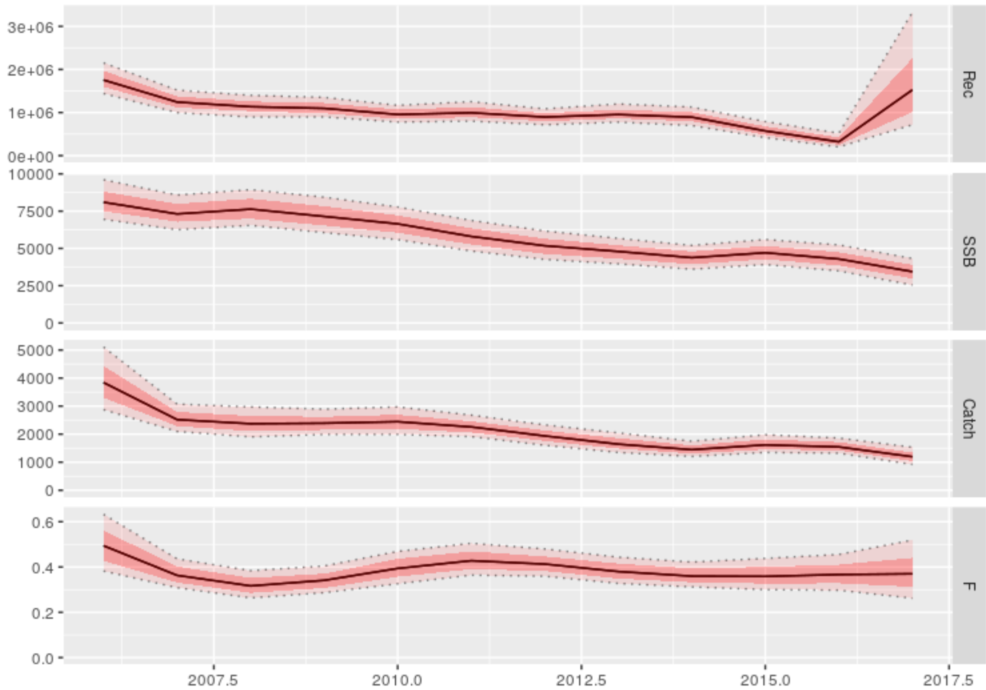


Figure 6.3.3.2.12 Norway lobster in GSA 17 and 18. Final results in GSA17 (Pomo) and 18.

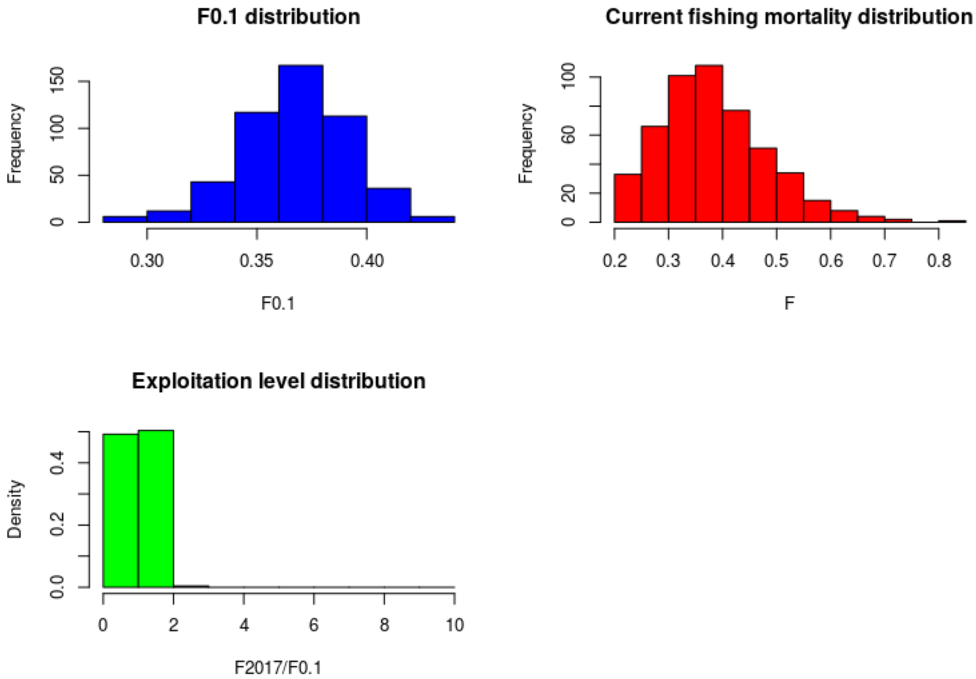


Figure 6.3.3.2.13 Norway lobster in GSA 17 and 18. Probability of F0.1 reference point, F current and level of exploitation in GSA17 (Pomo) and 18.

OUTSIDE POMO

Input data

As index was used a combined MEDITS survey. Length distribution by sex were converted in age by l2a tool (a4a package). Finally a combined index was obtained weighting each GSA index by the area (see previous explanations).

Index

year

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	9.16634	1.50152	0.57022	0.24044	0.22341	0.01000	0.40939	0.30843	0.40145	0.45847	0.51604	0.77721
1	75.67627	26.89022	30.65278	25.66332	15.75409	7.31804	9.80639	10.65374	13.24451	12.60605	16.28681	11.78271
2	20.43774	8.38285	10.04391	18.34992	10.97721	7.33052	4.28586	5.31622	6.39893	6.14195	7.62569	6.84102
3	6.74349	2.08791	6.50312	9.13875	7.23875	4.56654	3.16482	3.85779	3.38991	3.17853	3.37766	2.03981
4	2.09750	0.72696	2.99179	2.99439	3.24007	1.47714	1.29599	1.65825	1.34371	0.93565	1.40255	1.18674
5	1.85059	0.78968	2.03313	1.56629	0.75251	0.51082	0.30766	0.64277	0.45575	0.51779	0.78155	0.42781
6	1.75030	1.54448	4.68326	2.07981	1.05633	0.79812	0.36978	0.99100	0.59263	0.67989	0.65681	0.96373

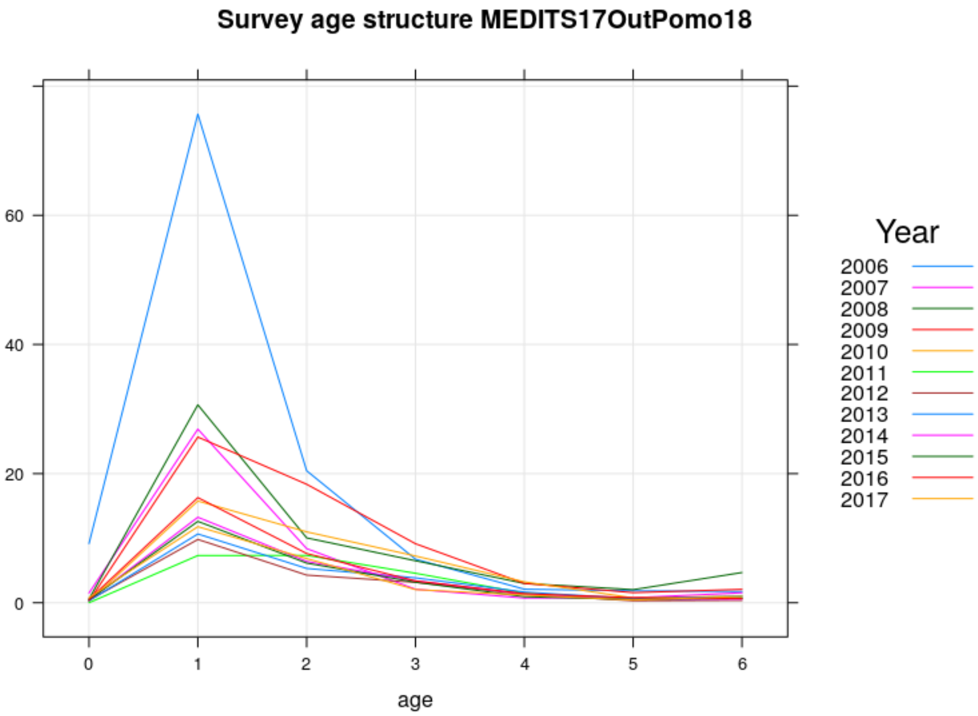


Figure 6.3.3.2.14 Norway lobster in GSA 17 and 18. MEDITS age composition in GSA17 (Outside Pomo) and 18.

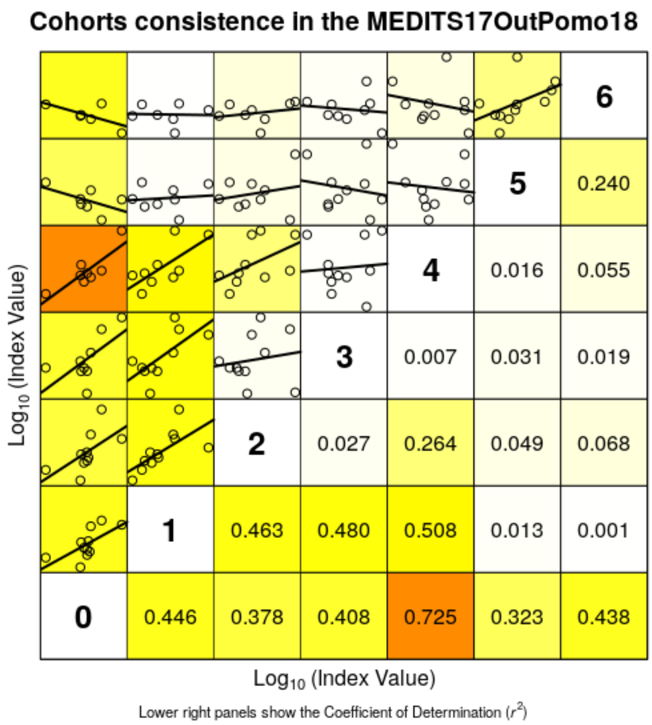


Figure 6.3.3.2.15 Norway lobster in GSA 17 and 18. Cohort consistency in MEDITS age matrix in GSA17 (Outside Pomo) and 18.

Catch in number were derived combining sliced (l2a) commercial length distribution by sex according to a weighting mean by sex (same GSA) and abundance (different GSAs). At the end of the process any SOP correction was needed.

Catch in number

age	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	3679.452	287.915	35.723	444.503	132.647	2651.203	395.071	717.089	592.788
1	103097.673	70601.545	35081.247	44706.594	58868.860	60784.441	40199.424	22889.004	27350.425
2	33582.286	47970.680	44058.412	38180.583	30577.534	21350.950	25351.131	25832.773	26801.125
3	15746.914	15292.317	12801.350	14499.933	12583.544	9125.030	10313.345	15291.407	9406.642
4	4644.037	2568.936	2576.727	3868.735	3347.859	2377.135	2928.706	4986.970	2473.224
5	1613.083	703.224	742.146	1173.565	1102.979	758.841	1022.192	1567.086	831.290
6	705.595	339.684	532.039	1066.636	869.902	440.400	664.546	1098.157	1219.573

age	2015	2016	2017
0	338.771	43.202	424.264
1	13943.359	6850.322	11384.480
2	15859.162	13641.404	16076.814
3	10400.794	10617.274	11360.251
4	4261.694	3555.840	4103.649
5	1272.324	1271.740	1212.434
6	944.877	918.138	953.530

units: 1000

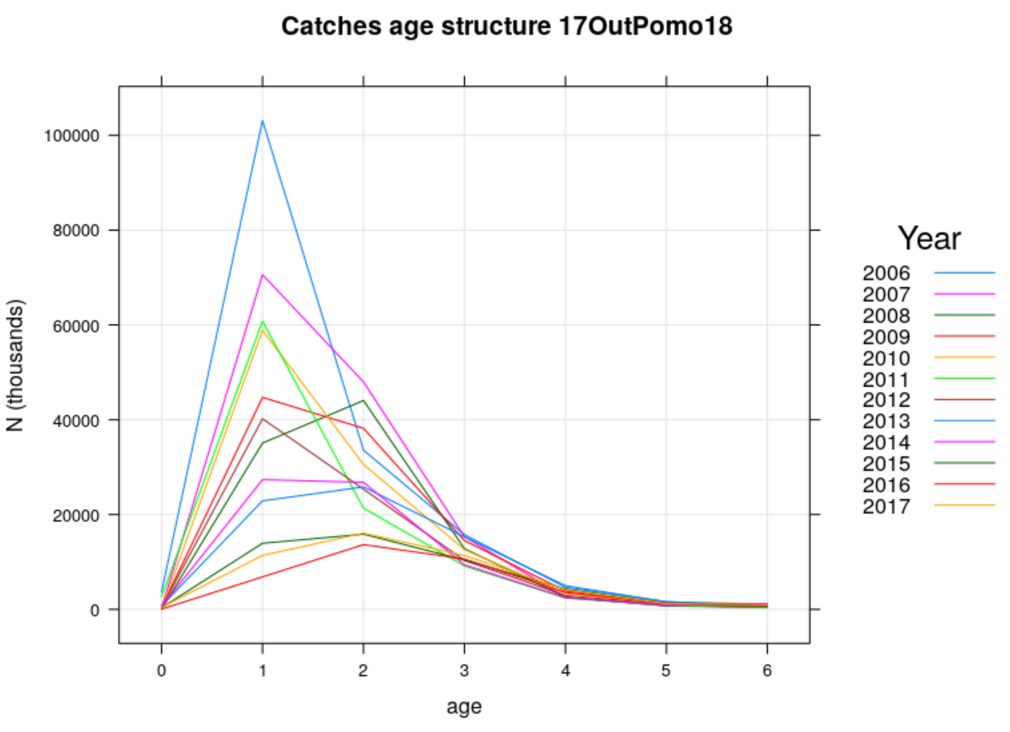


Figure 6.3.3.2.16 Norway lobster in GSA 17 and 18. Catch age composition in GSA17 (Outside Pomo) and 18.

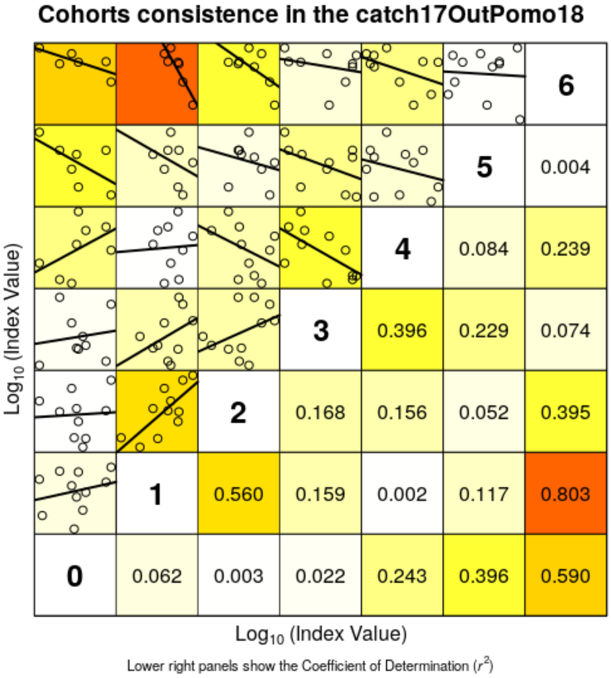


Figure 6.3.3.2.17 Norway lobster in GSA 17 and 18. Cohort consistency in catch age matrix in GSA17 (Outside Pomo) and 18.

All the other input data are reported in the previous sections (6.3.1 and 6.3.2). In Figure 6.3.3.2.18 the final input data are showed.

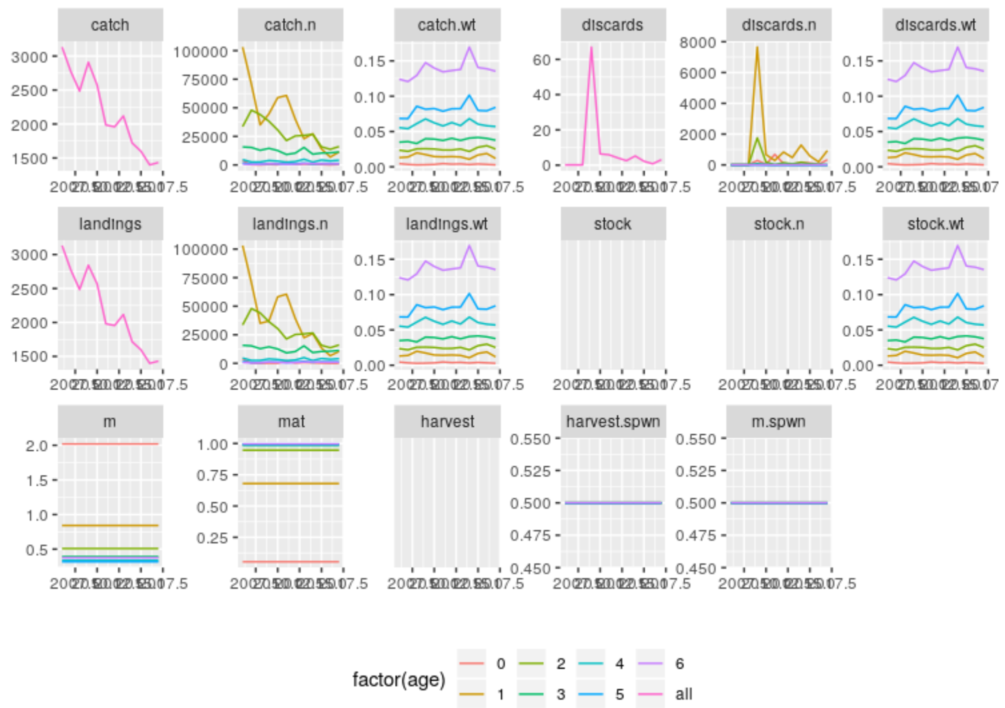


Figure 6.3.3.2.18 Norway lobster in GSA 17 and 18. a4a Input data in GSA17 (Outside Pomo) and 18.

MODEL SETTING AND DIAGNOSTIC

According to the diagnostic the best model choose was:

fmodel <- ~ factor(age)+s(year, k=6)

qmodel<- list(~ factor(replace(age,age>2,2)))

vmodel <- list(~1,~s(age, k = 3))

srmodel<- ~factor(year)
n1model<- ~s(age, k = 4)

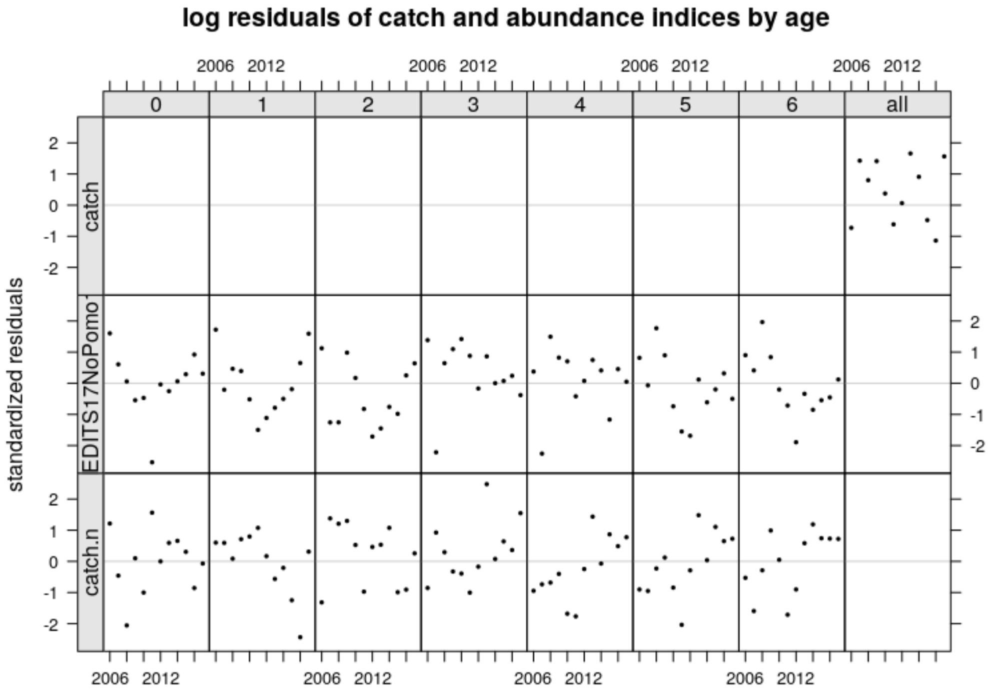


Figure 6.3.3.2.19 Norway lobster in GSA 17 and 18. Model residuals in GSA17 (Outside Pomo) and 18.

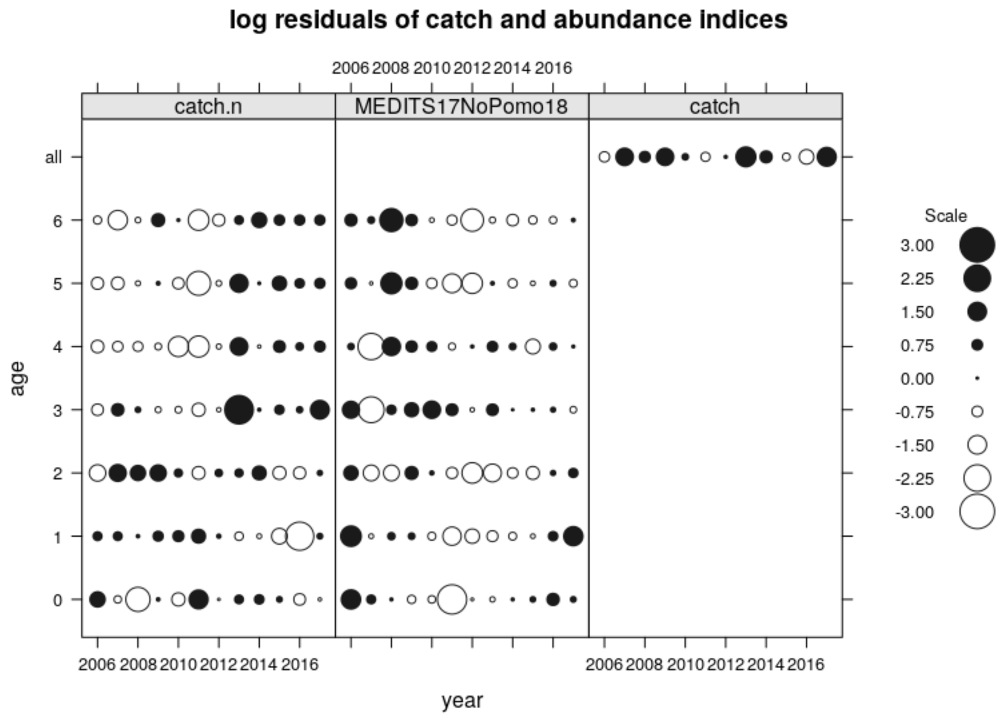
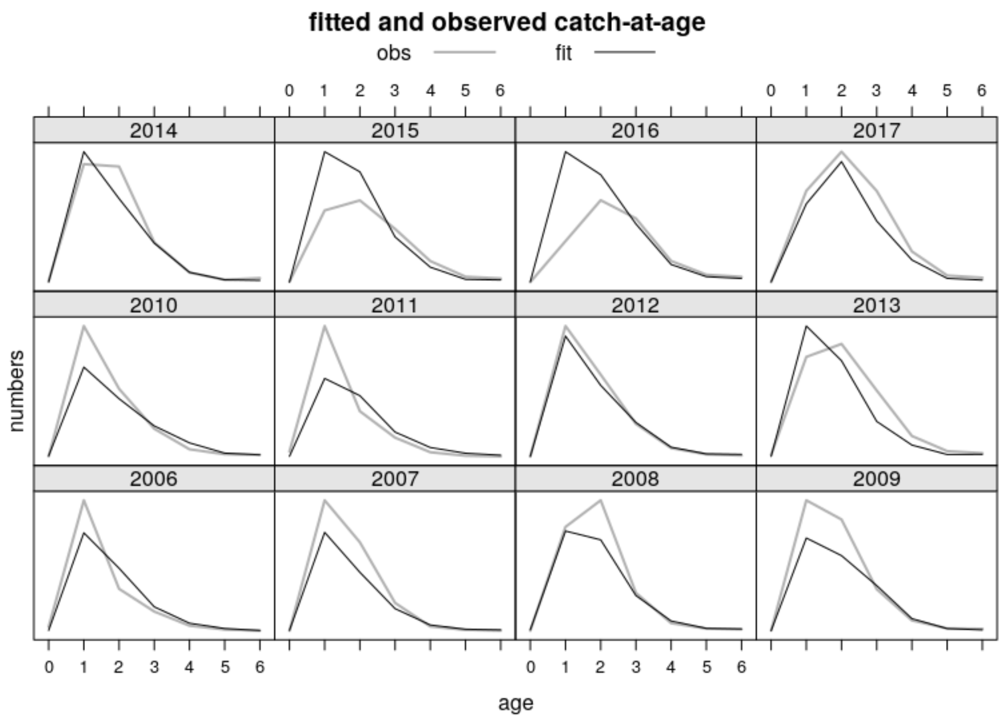


Figure 6.3.3.2.20 Norway lobster in GSA 17 and 18. Bubble plot of model residuals in GSA17 (Outside Pomo) and 18



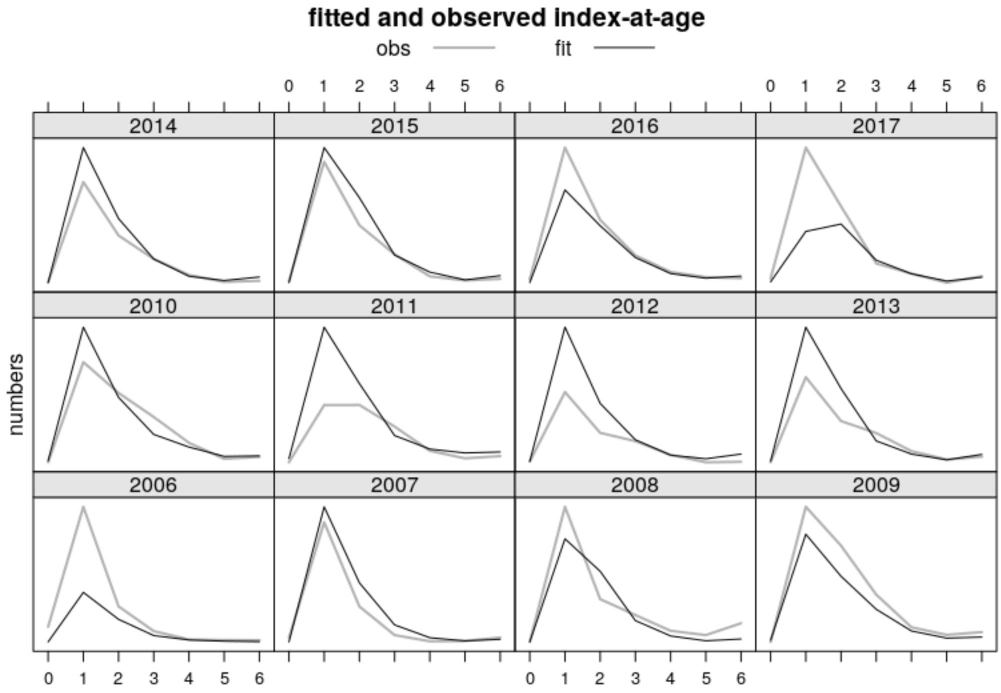


Figure 6.3.3.2.21 Norway lobster in GSA 17 and 18. Model fit in GSA17 (Pomo) and 18. Uppper panel catch fit and lower panel index fit.

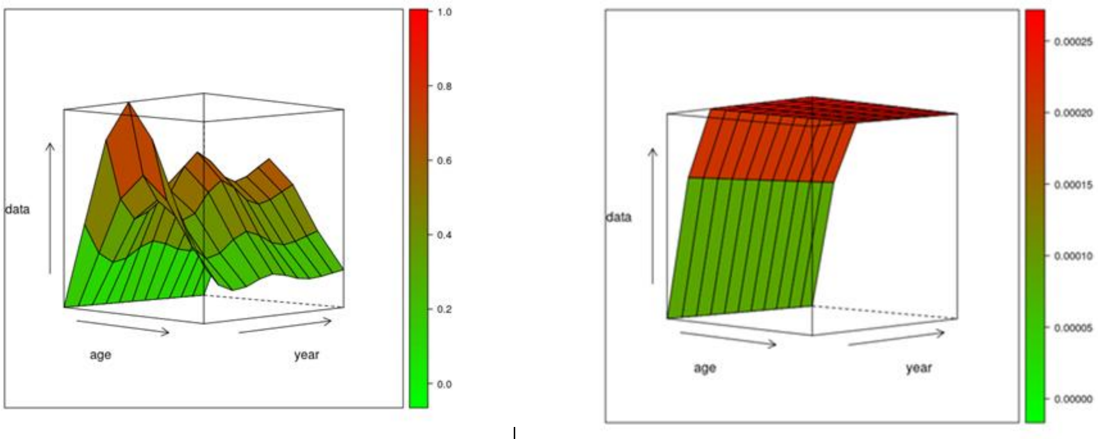


Figure 6.3.3.2.22 Norway lobster in GSA 17 and 18. Model fit in GSA17 (Outside Pomo) and 18. Left panel exploitation pattern and right panel catchability.

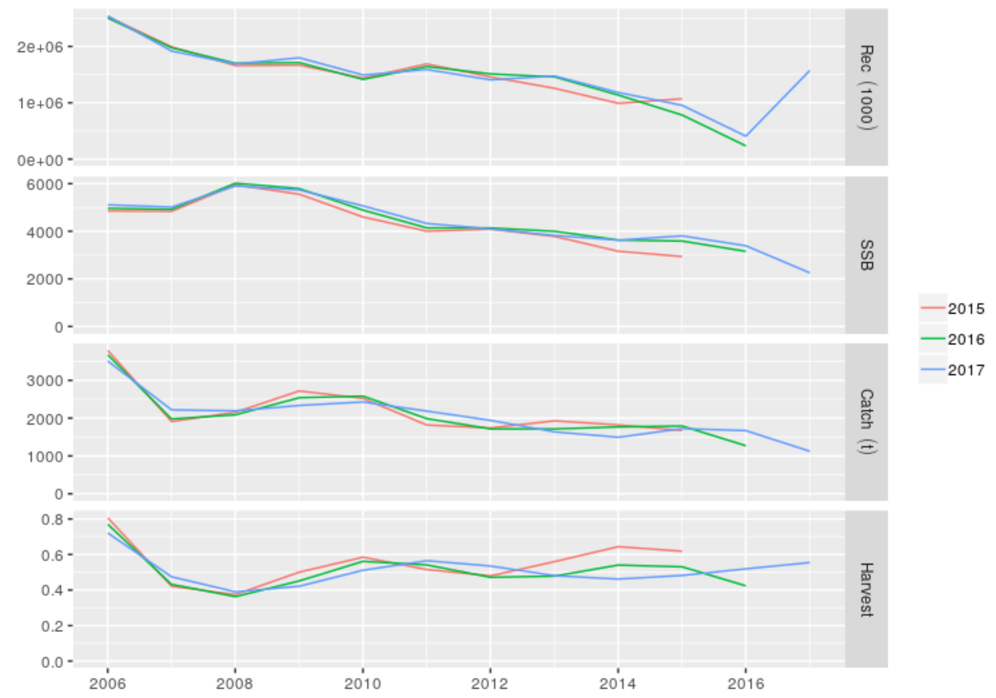


Figure 6.3.3.2.23 Norway lobster in GSA 17 and 18. Model retrospective analysis in GSA17 (Outside Pomo) and 18.

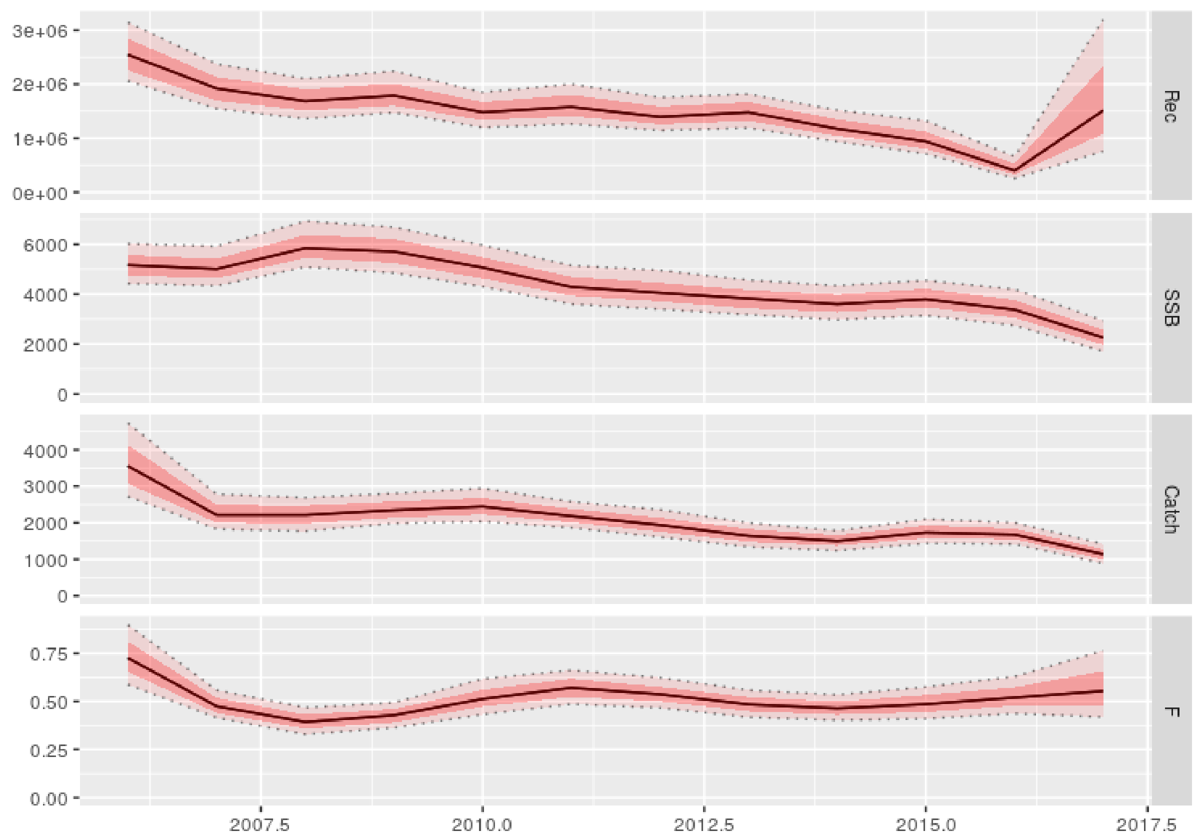


Figure 6.3.3.2.24 Norway lobster in GSA 17 and 18. Final results in GSA17 (Outside Pomo) and 18.

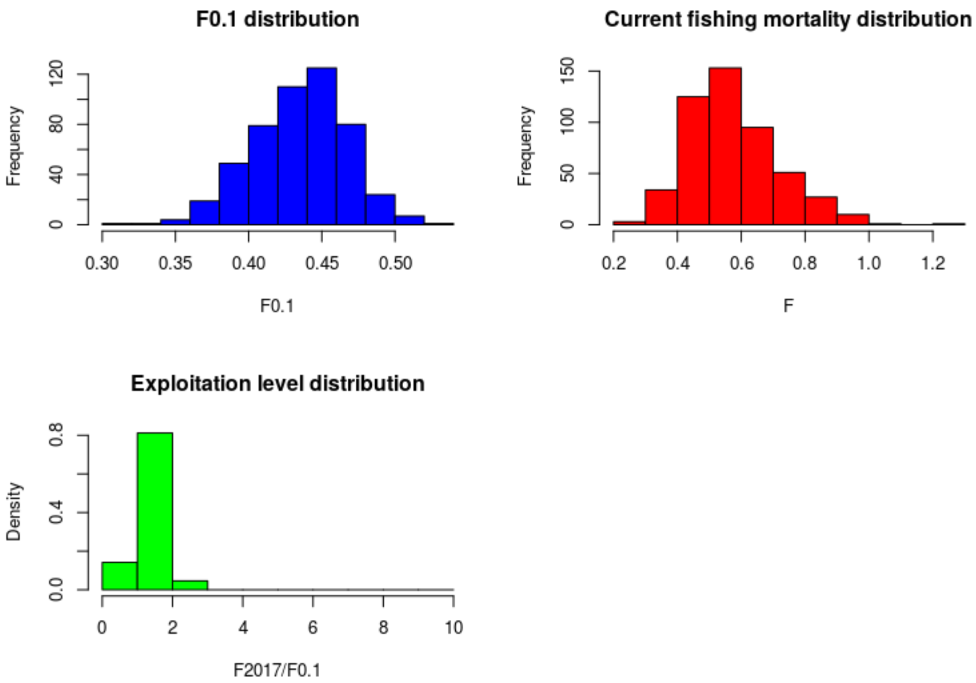


Figure 6.3.3.2.25 Norway lobster in GSA 17 and 18. Probability of F0.1 reference point, F current and level of exploitation in GSA17 (Outside Pomo) and 18.

FINAL COMPARISON

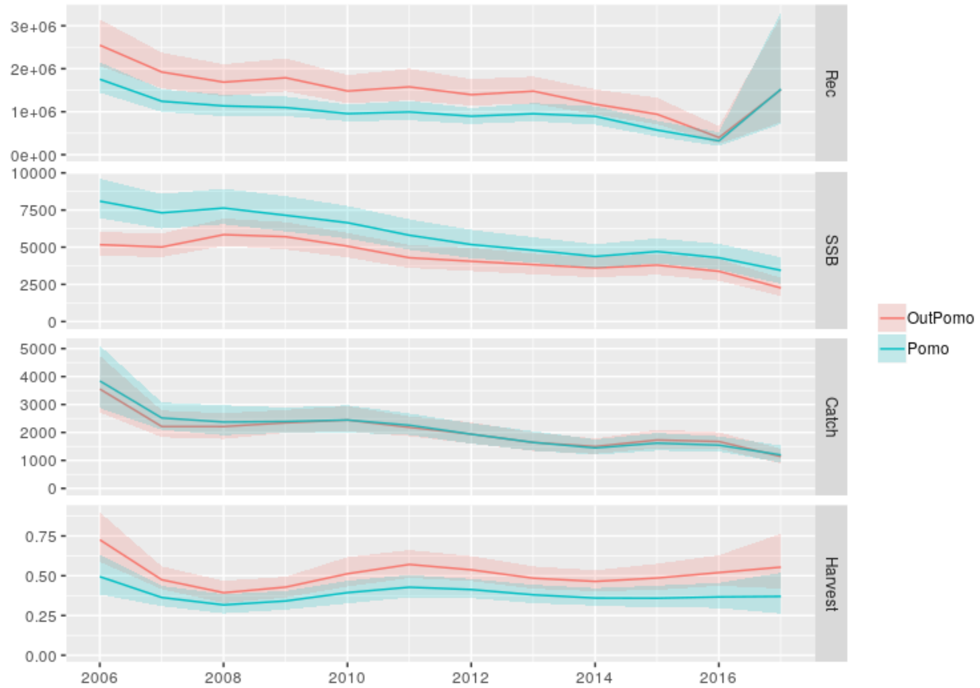


Figure 6.3.3.2.26 Norway lobster in GSA 17 and 18. Final comparison between the two scenarios

CONCLUSIONS

Comparison of the results from the two extreme data treatments assuming within and without Pomo Pit growth suggests that the assessments should not be expected to be sensitive to growth assumptions on the scale implied by the different size distributions found across the area (Figure 6.3.3.2.27). Nevertheless, due to some patterns in the residuals in the two age based models, suggests the fit in the age based models was not optimal. Also the shorter term trend in relative fishing mortality is rather different comparing with the one obtained from the longer term perspective given by the SPICT model (Figure 6.3.3.2.27). The EWG decided to maintain the use of the production model as final assessment (basically an update of the last assessment accepted in 2017)

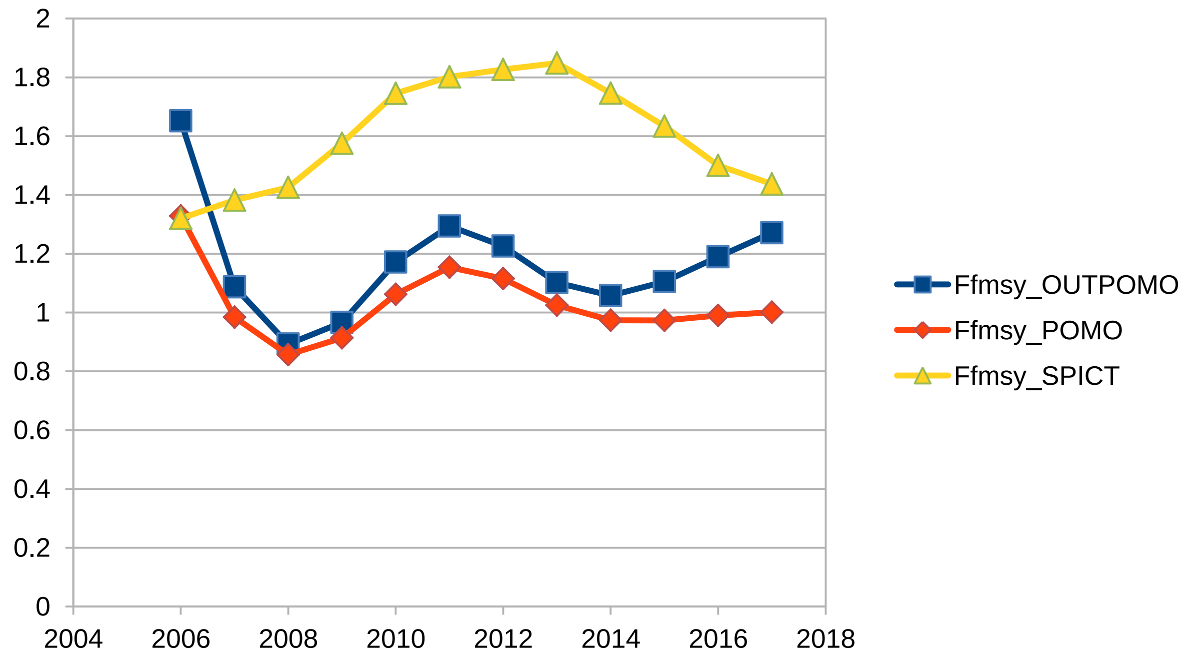


Figure 6.3.3.2.27 Norway lobster in GSA 17 and 18. Final comparison between models

The SPICT model accepted to assess Norway lobster in GSA 17-18 is SPICT model which uses the most complete data set fitted to the longest time series available covering also periods with high biomass and low F, some stock declines and recoveries. Model shows a continuous reduction in B/Bmsy since 60s, with values consistently below 1 since mid-90s with the last 3 years being among the lowest point of the series. In terms of F/Fmsy the model indicates an increasing since early ‘90s with values over 1 since mid-2000.

The status of the stock in 2017 using mean value by year, referred to the stochastic reference points (B_{MSY}s F_{MSY}s) is , F_{2017}/F_{MSY}s = 1.46 and B_{2017}/B_{MSYs} = 0.43. When referred to the deterministic reference points, the stock status in 2017, is F_{2017}/F_{MSYd}= 1.46 and B_{2017}/B_{MSYd} = 0.41.

6.3.4 Reference Points

The SPiCT model provides output set directly in the context of MSY, and the results are estimated by the model, however, these are less precise than the F/Fmsy and B/Bmsy results. Based on model Fmsy from stochastic reference points is F_{MSYs} = 0.453 y^{-1} (0.180 - 1.139) and B_{MSYs} = 4914 t (1993 - 12118) , while the deterministic reference points are F_{MSYd} = 0.454 and B_{MSYd} = 5147 t. Based on these results STECF-EWG 18-16 considers the stock has been depleted well below Bmsy and been overexploited (F>Fmsy) in the last years.

6.3.5 Short term Forecast and Catch Options

The SPiCT model was used to carry out a short term forecast with the following conditions:

Observed interval, index: 1960.00 - 2017.00
Observed interval, catch: 1970.00 - 2018.00

Fishing mortality (F) prediction: 2020.00
Biomass (B) prediction: 2020.00
Catch (C) prediction interval: 2019.00 - 2020.00

STF shows large uncertainties in the estimates as indicated by the 95% confidence boundaries around the predicted mean values. In general, the stock under the simulated F reductions does not recover over Bmsy by 2020 except for the no fishing scenario. The best performance in term of stock biomass for the options tested would be obtained by F at Fmsy which would bring B_{2020}/Bmsy to 0.73.

Predictions

	C	B	F	B/Bmsy	F/Fmsy	perc.dB	perc.dF
1. Keep current catch	1430.5	2072.1	0.692	0.422	1.527	-10.4	6.3
2. Keep current F	1731.2	2746.0	0.652	0.559	1.437	18.7	0.0
3. Fish at Fmsy	1494.4	3580.4	0.453	0.729	1.000	54.8	-30.4
4. No fishing	3.5	6542.7	0.001	1.331	0.001	182.8	-99.9
5. Reduce F 25%	1549.9	3415.7	0.489	0.695	1.078	47.6	-25.0
6. Increase F 25%	1813.4	2206.3	0.814	0.449	1.796	-4.6	25.0

95% CIs of absolute predictions

	C.lo	C.hi	B.lo	B.hi	F.lo	F.hi
1. Keep current catch	1430.4	1430.7	548.3	7829.8	0.185	2.589
2. Keep current F	986.3	3038.7	819.6	9200.6	0.206	2.057
3. Fish at Fmsy	821.5	2718.3	1307.7	9802.6	0.144	1.432
4. No fishing	1.5	8.4	3499.3	12233.0	0.000	0.002
5. Reduce F 25%	861.6	2787.9	1204.9	9683.0	0.155	1.543
6. Increase F 25%	1009.1	3258.7	552.2	8814.9	0.258	2.571

95% CIs of relative predictions

	B/Bmsy.lo	B/Bmsy.hi	F/Fmsy.lo	F/Fmsy.hi
1. Keep current catch	0.156	1.141	0.600	3.887
2. Keep current F	0.191	1.631	0.669	3.084
3. Fish at Fmsy	0.285	1.861	0.466	2.147

4. No fishing	0.567	3.126	0.001	0.003
5. Reduce F 25%	0.267	1.811	0.502	2.313
6. Increase F 25%	0.134	1.509	0.837	3.856

Full time series of forecasts are outlined in Table 6.3.5.1 and Figure 6.3.5.1

Table 6.3.5.1 Norway lobster in GSA 17-18. Short term forecasts of status quo and different fishing mortalities reductions

Forecast Scenario	Year	Fishing mortality (F)	Biomass (B)	Catch
Keep current catch	2018	0.704	2031.0	1430.5
	2019	0.692	2072.1	1430.5
	2020	0.673	2102.3	1430.5
Keep current F	2018	0.652	2568.3	1589.8
	2019	0.652	2746.0	1731.2
	2020	0.652	2866.1	1828.4
Fish at Fmsy	2018	0.453	3020.1	1203.9
	2019	0.453	3580.4	1494.4
	2020	0.453	3989.8	1715.8
No fishing	2018	0.001	4371.2	2.1
	2019	0.001	6542.7	3.5
	2020	0.001	8428.7	4.9
Reduce F 25%	2018	0.489	2934.3	1277.9
	2019	0.489	3415.7	1549.9
	2020	0.489	3762.5	1753.5
Increase F 25%	2018	0.814	2247.6	1856.8
	2019	0.814	2206.3	1813.4

	2020	0.814	2180.1	1786.0

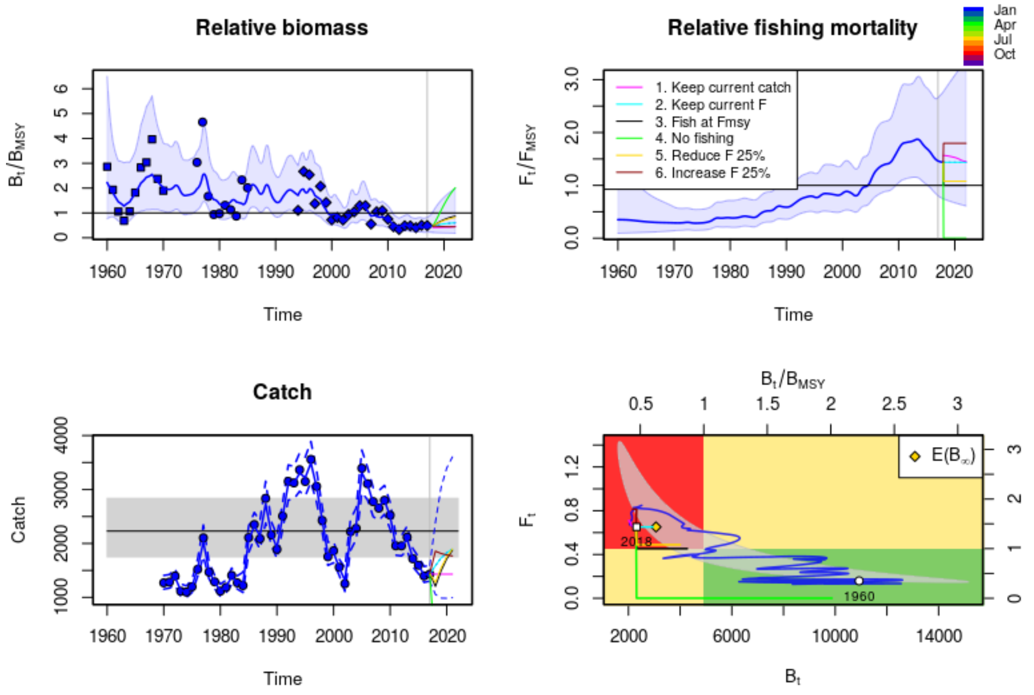


Figure 6.3.5.1 Norway lobster in GSA 17 and 18. Short term forecast for the period 2018-2021 according to different scenarios: 1 keep current catch, 2, keep current F, 3 fishing at Fmsy, 4 no fishing, 5 reduce F by 25%, 6 increase F by 25%.

All of the scenarios given by theSPiCT model short term forecast method, assume that the stock will grow in 2018 even if fishing is maintained at Fstatus quo. This assumption of standard stock growth does not seem to be appropriate given that the stock has been fished at similar Fs for several years now and has shown no significant stock growth. The EWG provided a STF based on no growth in 2018 at status quo F, in line with recent observations, this forecast is used for the advice (Table 6.3.5.2)

Table 6.3.5.2 Norway lobster in GSA 17-18. Short term assuming no stock growing in 2019.

Catch 2017	1430.5
f current (HR 2017) = Catch2017/B 2017	0.663
Fmsy from Spict Model (HR)	0.453
B 2017	2128.0
Bmsy From SPICT Model	4914.0
Blim = 40% Bmsy	1965.6

MSY Btrigger = Bpa = Blim*1.4	2751.8
HR 2017 (to check that F is HR in SPICT)	0.672
B 2017/Bpa (reduction because B<Bpa)	0.773
F target (MSY reduced)	0.350
Catch 2018/2019 at F=FMSY	964.0
Catch 2018/2019 F = F Reduced	745.4
Biomass status	0.433

6.4 Deep-Water Rose shrimp in GSAs 17, 18-19

6.4.1 Stock Identity and Biology

STECF EWG 18-16 was asked to assess the state of Deep-water rose shrimp stocks in the Adriatic and Ionian Sea by GSAs combined.

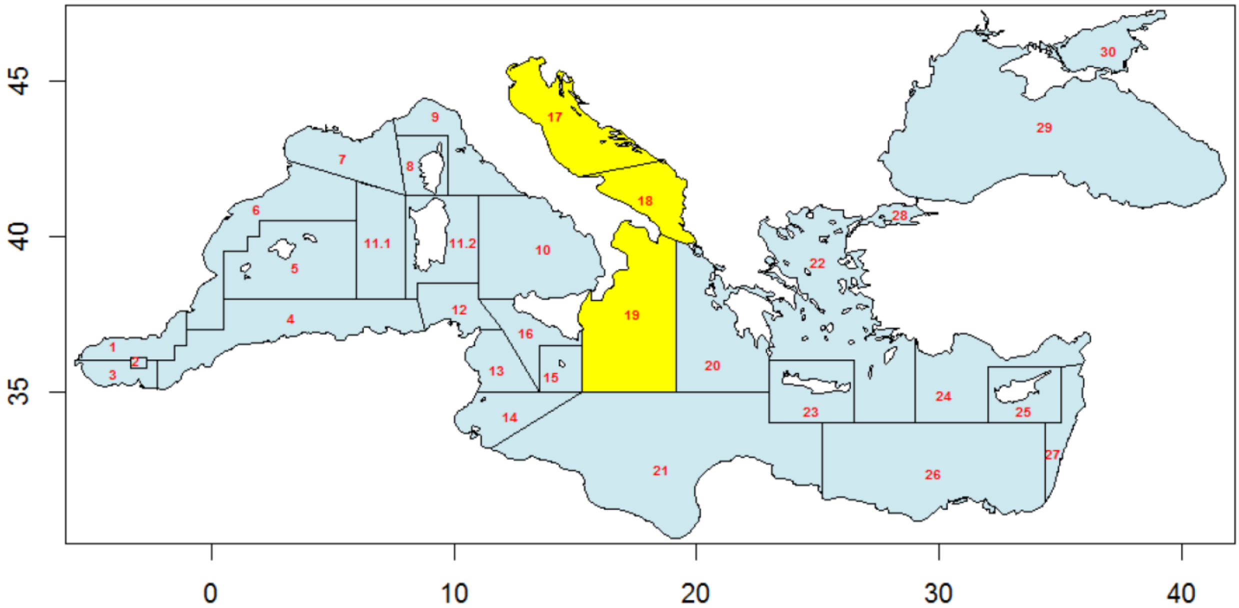


Figure 6.4.1.1. Deep-water rose shrimp in GSA 17-19. Geographical location of GSAs 17-18-19.

Age and growth

For *P. longirostris*, males and females are known to have different growth profiles, with males growing slower and reaching smaller size than females. The DCF data include information on the growth parameters by sex of in GSA 18-19, but not in GSA 17. However, since the sex ratio in the catches was not available in the DCF, was not possible to use it for the purposes of the DPS assessment. Growth parameter and length-weight relationship parameters for sex combined from DCF were used in the assessment as it was done in previous meetings (see Table 6.4.1.1).

Table 6.4.1.1 Deep-water rose shrimp in GSA 17-19. Parameters used for growth and weight at length taken from DCF data.

Growth Equation	$L\infty$	k	T_0
$L(t) = L_\infty *[1 - \exp(-K*(t-t_0))]$	45.0	0.6	-0.2
Weight at Length	a	b	
aL^b	0.0024	2.5372	

The same vector of proportion of mature individuals by age used in STECF EWG 17-09 was utilized by DEWG 18-16.

A vector of natural mortality was estimated by the Chen and Watanabe (1989) function using growth and length-weight relationship parameters for sex combined.

Maturity is taken from DCF data and given in Table 6.4.1.2.

Table 6.4.1.2. **Deep-water rose shrimp in GSA 17-19.** Maturity and Natural mortality parameters used in the assessment

Age	0	1	2	3+
Maturity	0.519	0.939	0.977	1
Natural mortality	1.75	0.938	0.748	0.673

Studies carried out in the Mediterranean indicate a variable reproductive strategy for this species. Some authors found that in the South Ionian the spawning of the deepwater rose shrimp females' is carried out during summer and that is more protracted in Montenegrin waters compared to Ionian waters (K. Kapiris et al., 2013). From other authors spawning is considered to occur through the year (D' Onghia et al., 1998). Then for the purposes of this assessment the spawning time was set at the mid-point of the year with 50% F and M occurring before spawning.

General description of Fisheries

Deep-water rose shrimp is targeted mainly by bottom trawlers in these areas. Deep-water rose shrimp is commercially important in the Adriatic Sea: it is targeted by trawlers (Italy, Croatia, Albania and Montenegro). The Southern Adriatic Sea makes a substantial contribution to the Italian Deep-water rose shrimp national fishery production, with an input comparable to that of the Strait of Sicily, accounting for about 13% of total production (Cataudella and Spagnolo, 2011).

In the northwestern Ionian Sea, fishing occurs from coastal waters to 700–750 m. The most important demersal resources in the northwestern Ionian Sea are represented by the red mullet (*Mullus barbatus*) on the continental shelf, hake (*Merluccius merluccius*), deep-water rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*) over a wide bathymetric range and the deep-water red shrimps (*Aristeus antennatus and Aristaeomorpha foliacea*) on the slope.

Management regulations

In Italy management regulations are based on technical measures, a restricted number of fishing licenses for the fleet and an area limitation (distance from the coast and minimum fishing depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban, that in southern Adriatic has been mandatory since the late eighties. In the GSA 19 the fishing ban has not been mandatory at all times, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it has been mandatory. Regarding small scale fishery management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) along the mainland, offshore Bari (180 km2, between about 100 and 180 m depth), and in the vicinity of Tremiti Islands (115 km2 along the bathymetry of 100 m) on the northern border of the GSA where a marine protected area (MPA) had been established in 1989. In the former only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30th, while in the latter the trawling fishery is allowed from November 1st to March 31 and the small scale fishery all year round. A recreational fishery using no more than 5 hooks is allowed in both the areas. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

In Montenegro, management regulations are based on technical regulations, such as mesh size (Official Gazette of Montenegro, 8/2011), including the minimum landing sizes (Official Gazette of Montenegro, 8/2011), and a regulated number of fishing licenses and area limitation (no–fishing zone up to 3 NM from the coastline or 8 NM for trawlers of >24 m LOA). Currently there are no MPAs or fishing bans in Montenegrin waters.

In Albania, a new law "On fishery" has now been approved, repealing the Law n. 7908. The new law is based on the main principles of the CFP, it reflects Reg. 1224/2009 CE; Reg.1005/2008 CE; Reg. 2371/2002 CE; Reg. 1198/2006 CE; Reg. 1967/2006 CE; Reg. 104/2000; Reg. 1543/2000 as well as the GFCM recommendations. The legal regime governing access to marine resources is being regulated by a licensing system. Also concerning conservation and management measures, minimum legal sizes and minimum mesh sizes are those proposed by EU Regulations. Albania has already an operational vessel register system. It is forbidden to trawl at less than 3 nautical miles (nm) from the coast or inside the 50m isobath when this distance is reached at a smaller distance from the shore.

Since the accession of Croatia to the EU the 1st of July 2013, the same regulations as in the Italy are implemented. Furthermore the following regulations are applied:Bottom trawl fisheries is closed one and half NM from the coast and island in inner sea, 2 NM around island on the open sea, and 3 NM about several island in the central Adriatic. For vessel smaller than 15 meters, according derogation in sea deeper than 50 meters bottom trawl fisheries is forbidden till 1NM of the coast. Bottom trawl fishery is closed also in the majority of channel area and bays. About 1/3 of the territorial waters is closed for bottom trawl fisheries over whole year and additionally 10% is closed from 100-300 days per years. Minimum mesh size on the bottom trawl net was 20 mm ("knot to knot") in the open sea, and 24 mm ("knot to knot") in the inner sea. Recently, mesh site regulation is according EC 1967/2006 (ie. 40 mm square or 50 mm diamond). In 2015 the no-take zone was established in Jabuka Pit. The establishment of Marine managed area (MMA) was based on long-time assessment of biological resources and analysis carried out by working group through FAO AdriaMed project that showed a decline in biomass of these commercial species. The proposed MMA covers the waters closed to trawling through a bilateral agreement between Republic of Italy and Republic of Croatia. The Pit was re-opened to trawling in 2016. Recently, following the growing support for a MMA in the Jabuka/Pomo Pit, Croatia and Italy agreed to reintroduce a fishing closure from the 1st of September 2017 to 31st of August 2020. Other interventional fisheries regulation measures were introduced in Croatia such as temporal ban of trawl fisheries in open part of central Adriatic and in channel area of northern Adriatic. The aim of those measures were protection of commercially important species (e.g. European hake and Norway lobster) in critical period (spawning or recruitment period).

6.4.2 DATA

All data were taken from 2018 DCF data call.

6.4.2.1 CATCH (LANDINGS AND DISCARDS)

Catch data were reported to STECF EWG 18-16 through the DCF. In GSAs 17-18, and 19, most of the landings come from otter trawls. DCF data coming from other gear were considered sampled inconsistently and were not included in the stock assessment.

Landings by year and fleet are presented in figure 6.4.2.1.1 and Table 6.4.2.1.1.

Table 6.4.2.1. **Deep-water rose shrimp stocks in GSAs 17-19**. Landings and discards data in tonnes by fleet from DCF 2018.

Landings

area	country	gear	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
17	HRV	OTB													363	536	655	833
17	ITA	OTB					54					92		84	202	279	471	520
17	MLT	OTB														0		
18	ITA	-1	244	496			9											
18	ITA	GNS		67	7													
18	ITA	GTR			1													
18	ITA	LLS			1													
18	ITA	OTB	903	1253	1848	1181	1465	863	766	939	888	870	523	734	638	651	996	1109
19	ITA	-1	365	745	0	0												
19	ITA	FPO			15													
19	ITA	GNS			7													0
19	ITA	GTR	3										0		2			
19	ITA	LLS			9													
19	ITA	OTB	738	646	1170	1243	1245	608	785	767	716	593	488	334	422	622	647	693
19	ITA	PS	20			1												
19	ITA	PTM					0											
19	ITA	SB			0	0												
19	ITA	SV			0	0												

Discards

area	country	gear	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
17	HRV	OTB														0	2	11
17	ITA	OTB										3		2	28	37	207	73
18	ITA	OTB								31	18	5	7	12	8	14	21	42
19	ITA	OTB					19			55	36	13	8	20	9	12	25	45

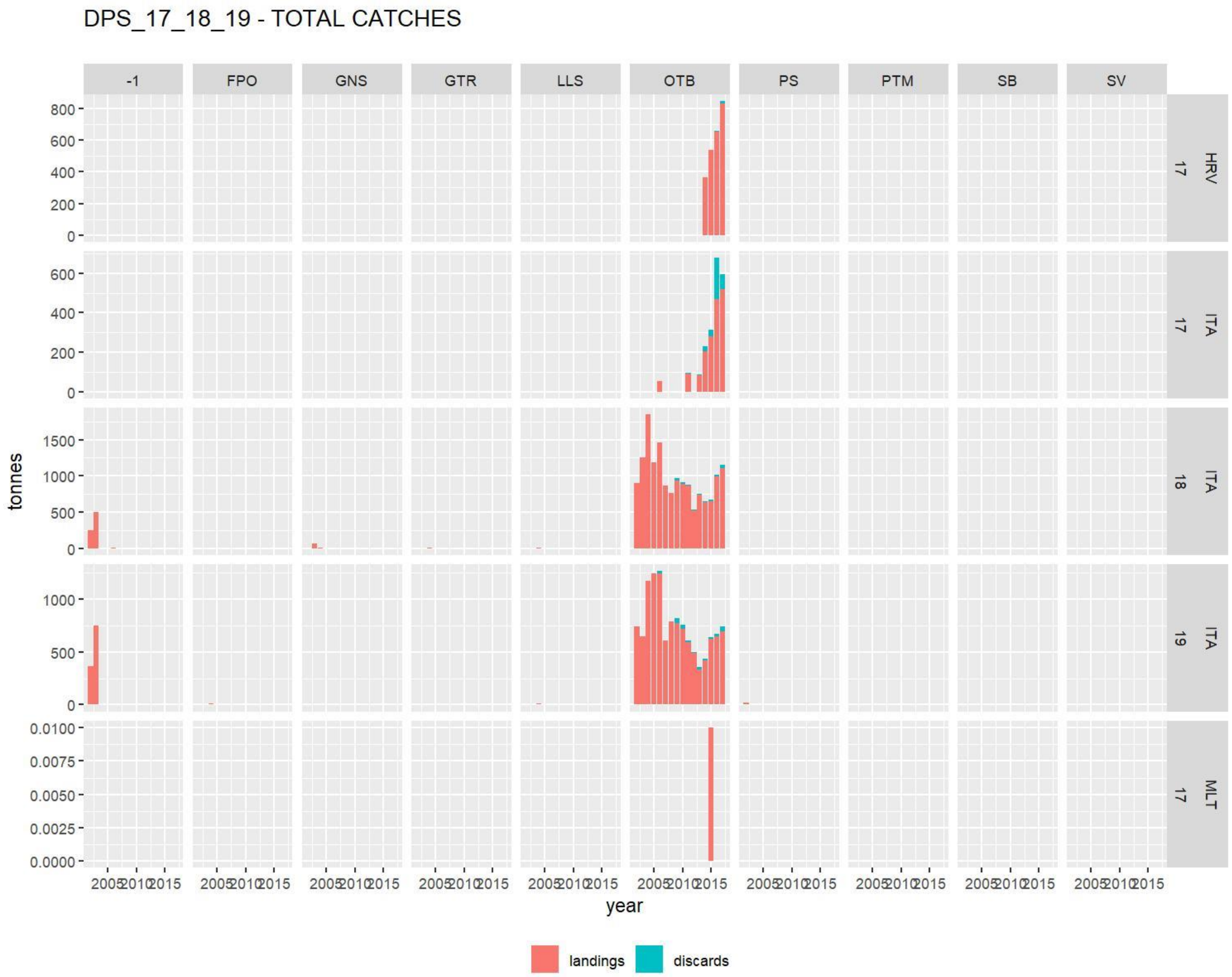


Figure 6.4.2.1. **Deep-water rose shrimp in GSA 17-19.** Landings and discards data in tonnes by fleet. from DCF 2018.

In the rest of the report, we will refer to and present only data for otter trawl and we will not consider the data from Malta fleet that occurs only in 2015 and seems to be not consistent with the time series.

Landings data for GSA 17 were incomplete (Table 6.4.2.1.2). Italian landings were present just for 2006, 2011, and from 2013 to 2017. Croatian landings were present just from 2014 to 2017 in the DCF database because previously there was no obligation to monitor that species. Landings data for GSA 18 were incomplete for Albania and Montenegro. Landings data for Albania were obtained from last report from 2007,2008 and 2009 and FISHSTAT from 2010 onward.Landing data from Albania were updated for the most recent five years. The Albanian landings update has been included, this gives a 3.5 to 5 fold increase in reported Albanian landings from 2012 to 2016, increasing total catches by all countries by +50% in 2012 (when catches were previously at their lowest) but by less (+25%) in 2016, as catches by most countries are seen to increase from 2012 onwards, as does the MEDITS index (see Section 6.4.2.3). The EWG discussed this and there did appear to be an increase in Albanian effort during this period, though the full extent of the catch increases and the validity of the landings values could not be verified. Data from Montenegro by last report (EWG 17-09) and originally derived from the GFCM assessment in 2017 were used. Landings data for GSA 19 were complete.

Discards were reported through DCF for GSA 18 and GSA 19 since 2010, for GSA 17 in 2006, 2011 and 2013-2017 for Italy and since 2008 for Croatia; no information was available neither for Albania nor for Montenegro (Table 6.4.2.1.2).

Table 6.4.2.1.2. **Deep-water rose shrimp in GSA 17-19.** Landings and discards data in tonnes by OTB as reported in the JRC repository (from DCF 2018).

DCF 2018 (OTB)	area	country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Land	17	HRV													363	536	655	833
Land	17	ITA					54					92		84	202	279	471	520
Land	18	ITA	903	1253	1848	1181	1465	863	766	939	888	870	523	734	638	651	996	1109
Land	19	ITA	738	646	1170	1243	1245	608	785	767	716	593	488	334	422	622	647	693
Disc	17	HRV														0	2	11
Disc	17	ITA										3		2	28	37	207	73
Disc	18	ITA								31	18	5	7	12	8	14	21	42
disc	19	ITA					19			55	36	13	8	20	9	12	25	45

For the puproses of the assessment EWG 18-06 reconstructed missing data taking in to account all the available information to fill gaps by fleet (i.e. By GSA, country and gear).

Missing landing data were taken from the previous STECF EWG 17-09. When landings where not present neither in JRC database nor in the previous STECF EWG 17-09 report they were rebuilded as the average landing value of the closest 5 years (Table 6.4.2.1.3, Figure 6.4.2.1.2).

Table 6.4.2.1.3. Deep-water rose shrimp in GSA 17-19. Landings data in tonnes by OTB as recontstruct by EWG18-16. The landings data present in the DCF database are in white. Landing reconstructed based on the mean proportions between landings and discards in the time series of each fleet are highlighted. Landings taken from previous report are in bold.

area	country	gear	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
17	HRV	OTB	141	141	141	141	141	141	**71**	**138**	**174**	**151**	**169**	**315**	363	536	655	833
17	ITA	OTB	57	57	57	57	**54**	**70**	**54**	**44**	**65**	92	**53**	84	202	279	471	520
18	ITA	OTB	903	1253	1848	1181	1465	863	766	939	888	870	523	734	638	651	996	1109
18	ALB	OTB	222	222	222	222	222	**309**	**309**	**275**	7	209	1170	1210	1430	1290	1460	1473
18	MNE	OTB	35	35	35	35	35	**39**	**39**	**36**	**32**	**27**	**22**	**31**	**28**	**31**	**32**	35
19	ITA	OTB	738	646	1170	1243	1245	608	785	767	716	593	488	334	422	622	647	693

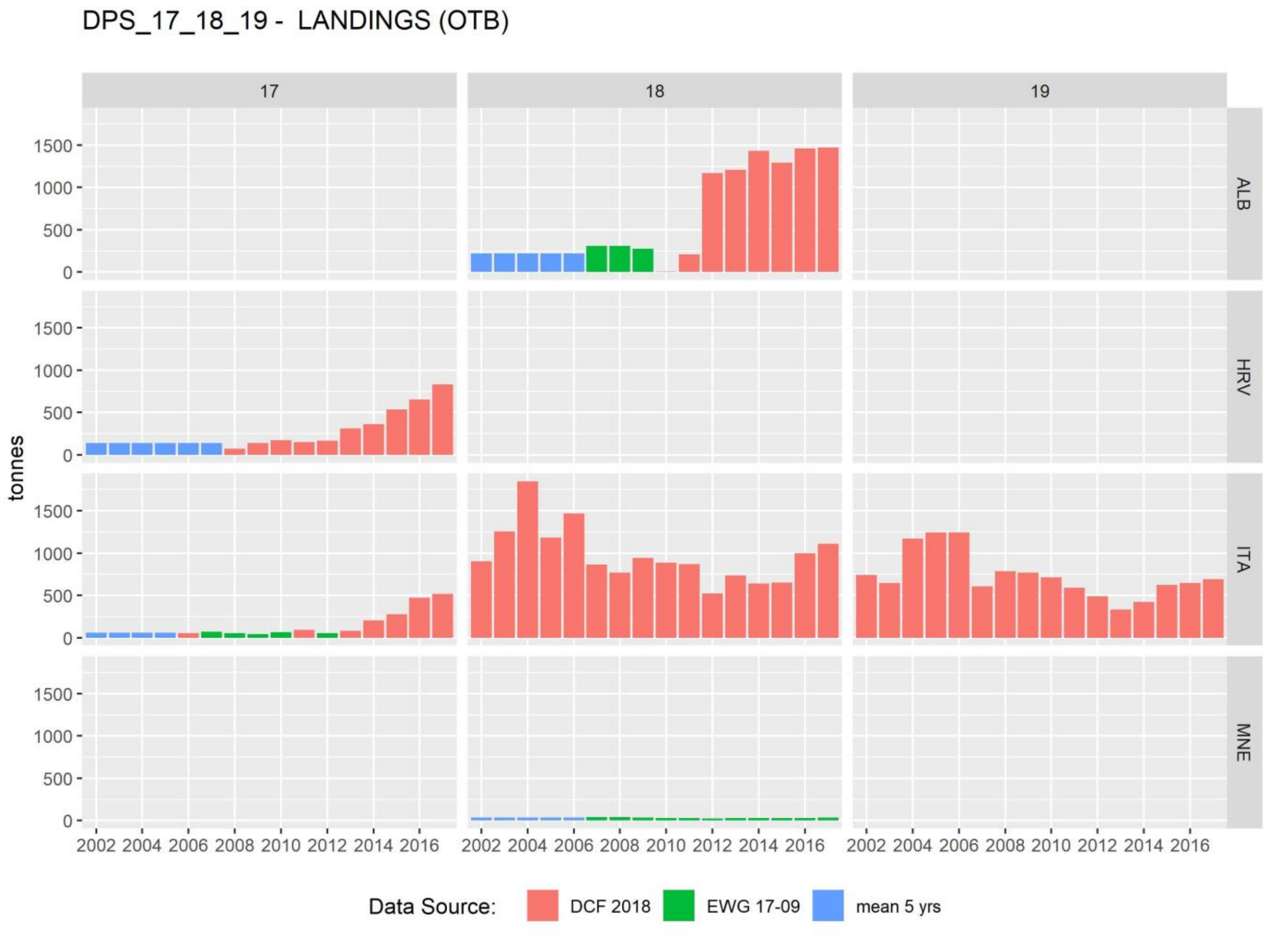


Figure 6.4.2.1.2. **Deep-water rose shrimp in GSA 17-19.** Total landings in tonnes by fleet and data source.

To fill gap in discards by country and area in missing years EWG 18-16 first used the DCF db at fleet segment level by year. Missing data were reconstruct by applying to landings the mean proportions between discard and landings found in other fleet segment of the same year. When no discard information were available data were derived by the mean value of discards for the same GSA and country in the neighboroud five years (Table 6.4.2.1.4, Figure 6.4.2.1.3).

Table 6.4.2.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Discards data in tonnes by OTB as recontstruct by EWG18-16. The discards data present in the DCF database are in white. Discards reconstructed based on the mean proportions between landings and discards for each fleet of the same year are in bold and red. Discards reconstructed based on the mean proportions between landings and discards of the available time series. Discards taken from previous report are in bold character.

area	country	gear	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
17	HRV	OTB	0.8	0.8	0.8	0.8	0.8	0.8	0.4	0.8	1.0	0.8	0.9	1.7	2.0	0.1	1.9	11.2
17	ITA	OTB	4.3	4.3	4.3	4.3	8.2	**6.2**	**4.7**	**3.9**	**5.7**	3.2	**4.6**	1.6	28.1	36.9	206.9	73.0
18	ITA	OTB	**16.6**	**23.1**	**34.0**	**21.8**	**23.8**	**15.9**	**16.0**	31.0	17.7	5.3	7.2	12.3	7.7	13.9	20.8	42.3
19	ITA	OTB	**26.8**	**23.5**	**42.5**	**45.2**	**19.0**	**22.1**	**28.5**	54.6	36.1	13.5	8.0	20.4	8.9	12.0	25.5	44.7

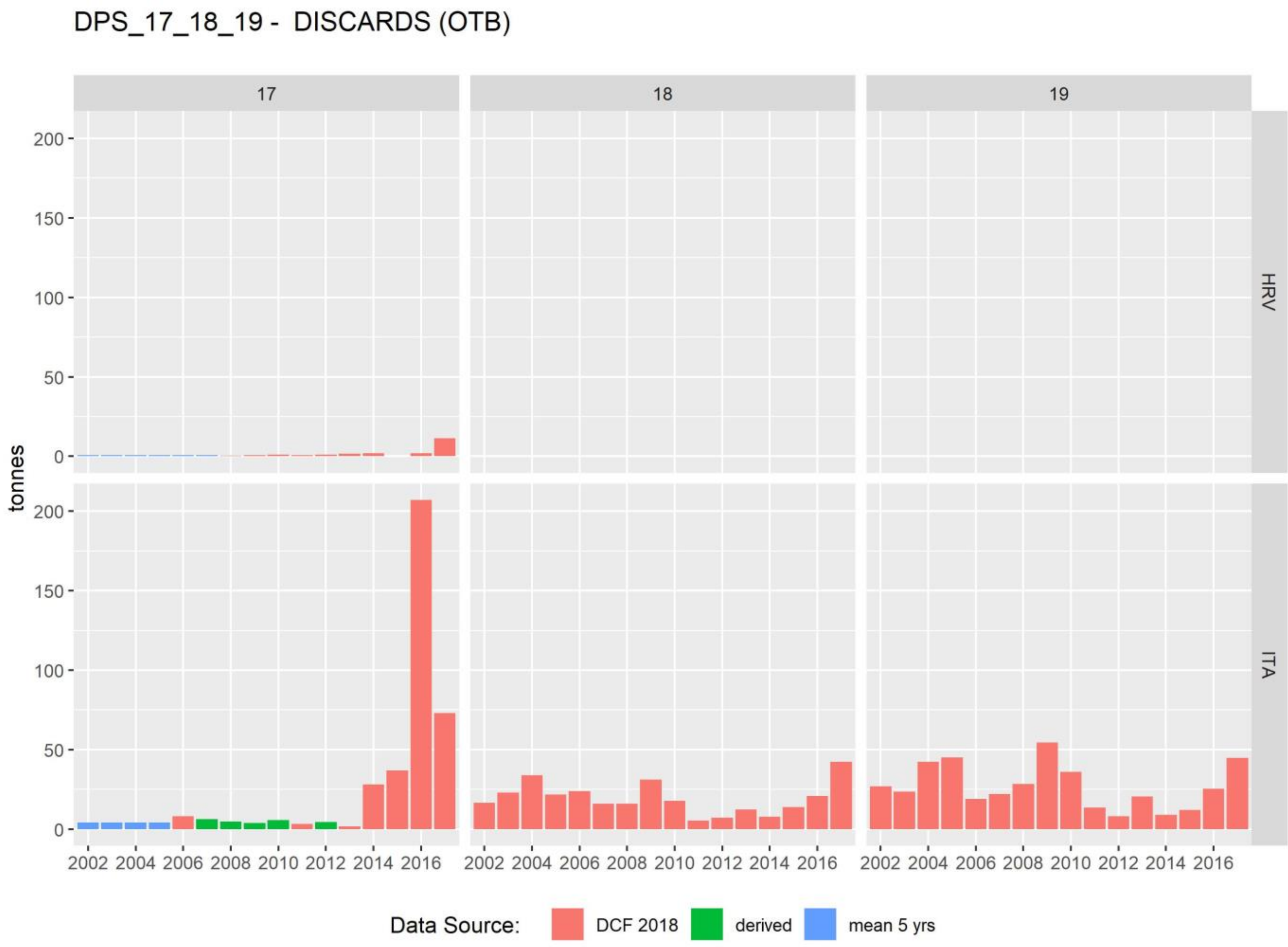


Figure 6.4.2.1.3. **Deep-water rose shrimp in GSA 17-19.** Total discards in tonnes by fleet and data source.

Landings and discards data as reconstructed by fleet where then summarised by year to be used as input data for the assessment (Table 6.4.2.1.5, Figure 6.4.2.1.4).

Table 6.4.2.1.5. **Deep-water rose shrimp in GSA 17-19.** Total landing, discards and catch by year as reconstructed by EWG 18-16.

OTB	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
discards	48.5	51.7	81.6	72.1	51.8	45	49.6	90.3	60.5	22.8	20.7	36	46.7	62.9	255	171
landings	2096	2354	3472	2879	3160	2029	2024	2200	1881	1942	2424	2708	3082	3409	4262	4663
catch	2144	2406	3554	2951	3212	2074	2074	2290	1942	1965	2445	2744	3129	3472	4517	4835

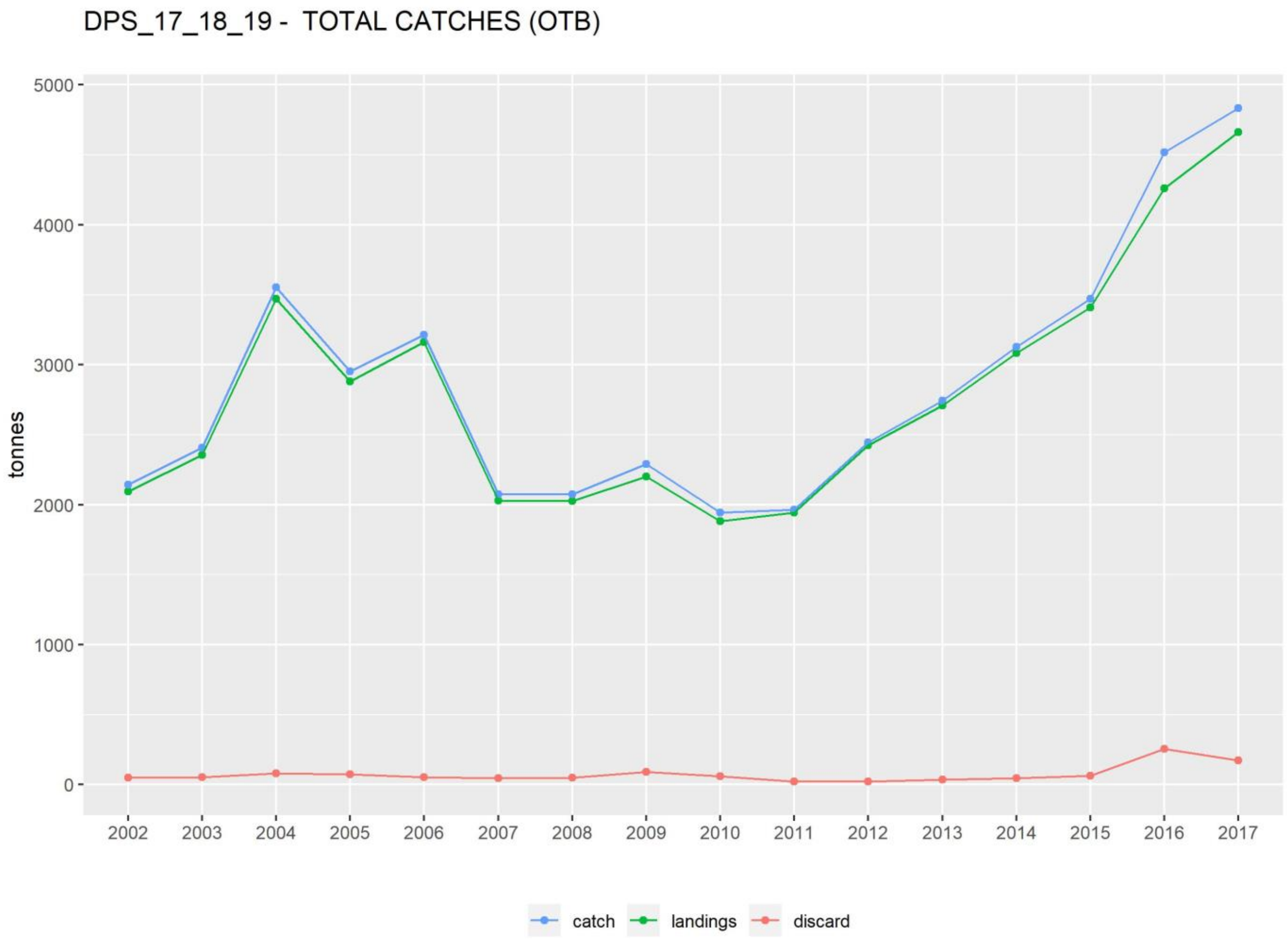


Figure 6.4.2.1.4. **Deep-water rose shrimp in GSA 17-19.** Total landing, discards and catch by year as reconstructed by EWG 18-16.

Information on landings at length is available for the whole time series (2002-2017) for Italy in GSA 18-19. For GSA 17 is only available in 2006, 2011 and 2013-2017 for Italy and from 2014 onwards in Croatia (Figure 6.4.2.1.5)

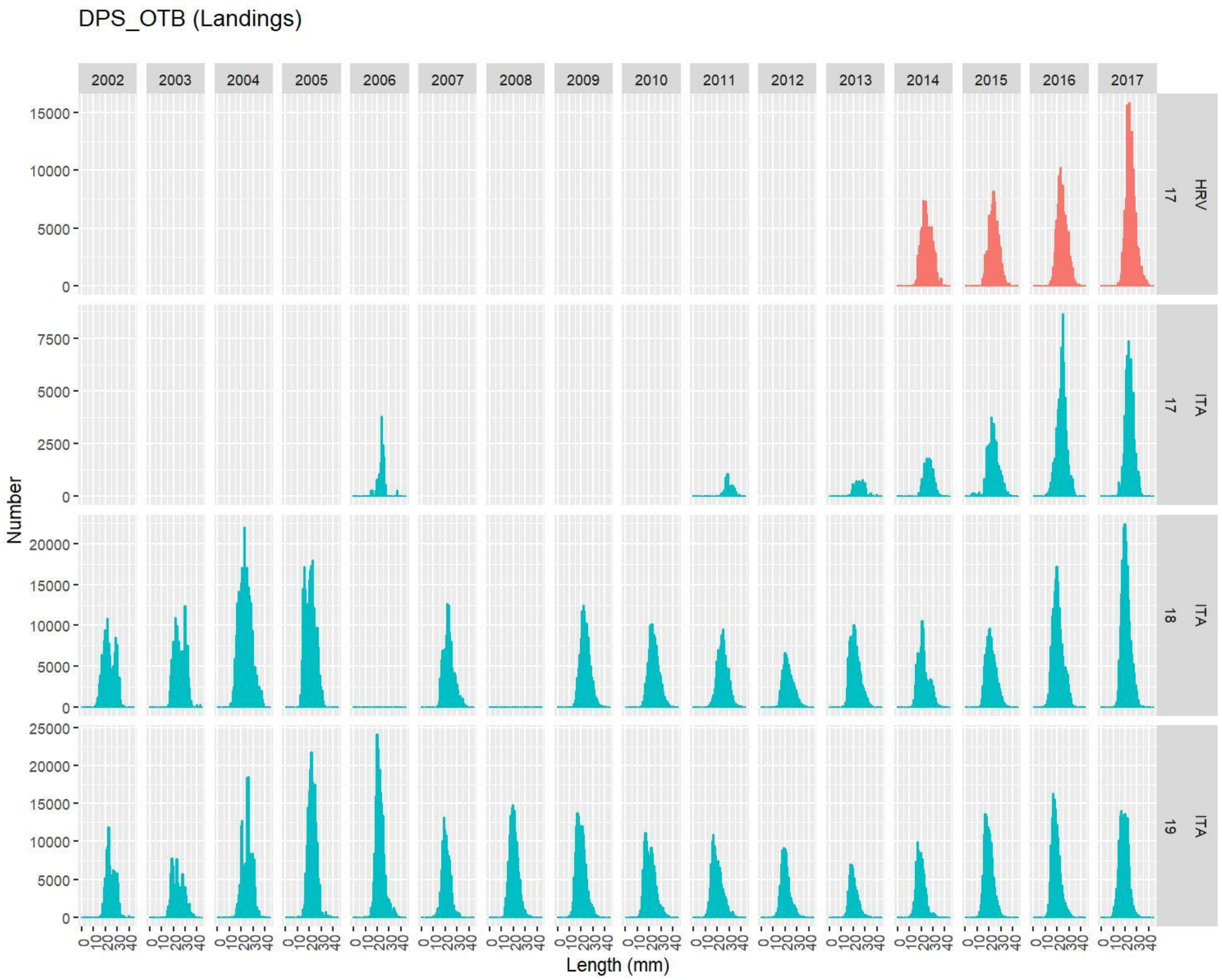


Figure 6.4.2.1.5. **Deep-water rose shrimp stocks in GSAs 17-19.** Length frequency distribution of the landings by year and fleet.

Information on discards at length is available since 2009 for Italy in GSA 19 and GSA18. For GSA 19 length are present also for 2006. For GSA 17 data at length are available in 2011 and from 2013 onwards for Italy and from 2015 onwards for Croatia (Figure 6.4.2.1.6)

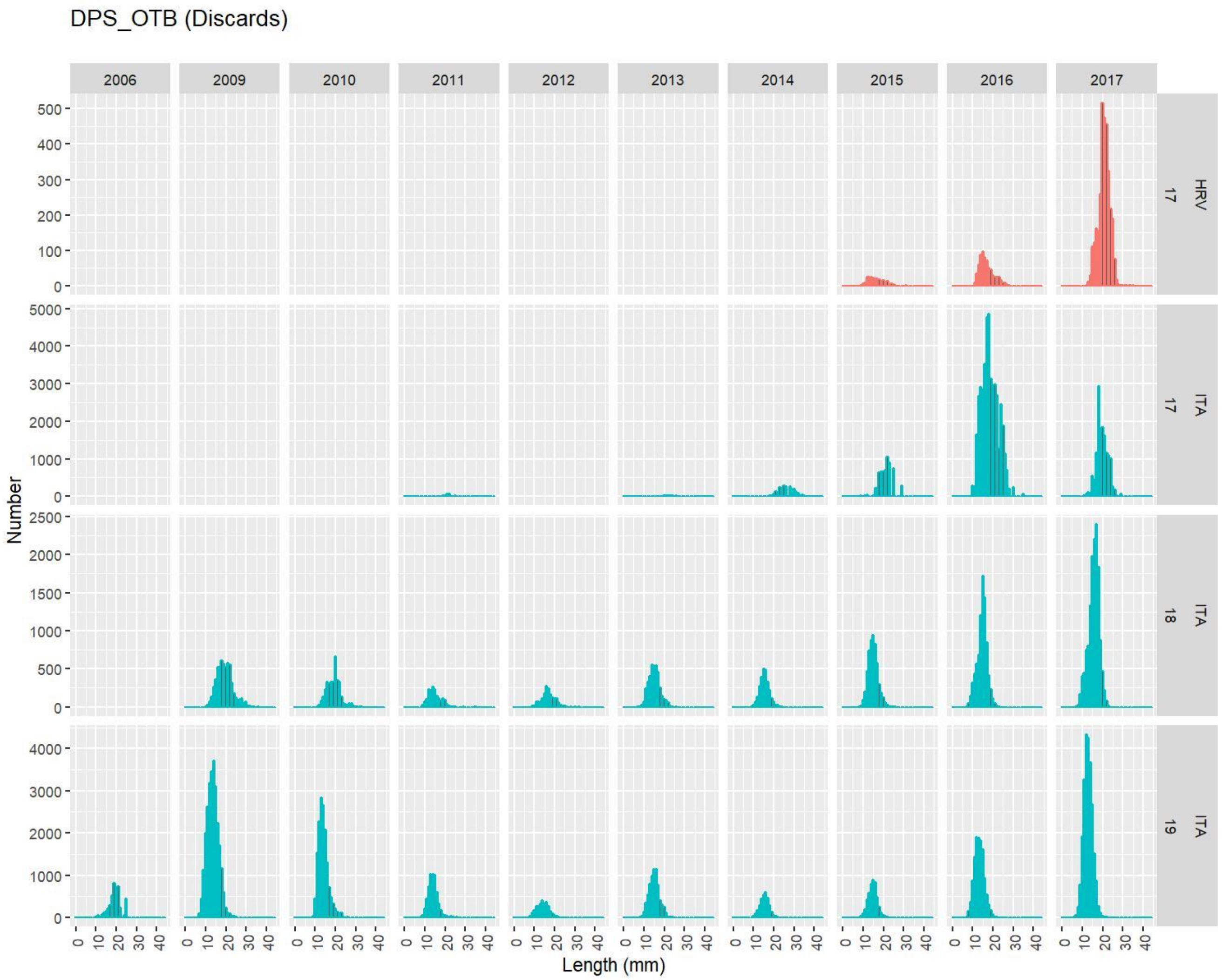


Figure 6.4.2.1.6. **Deep-water rose shrimp in GSA 17-19.** Length frequency distribution of the discards by year and fleet.

Discards have been included in the total catches,the assessment is based on these catches.

6.4.2.2 EFFORT

Fishing effort data were reported to STECF EWG 18-12 through DCF. Some effort reported in some year by France and Malta is removed to better see the effort ripartion among countries in the area studied. Nominal effort expressed as engine power (kW) per fishing days is reported in Figure 6.4.2.2.1.

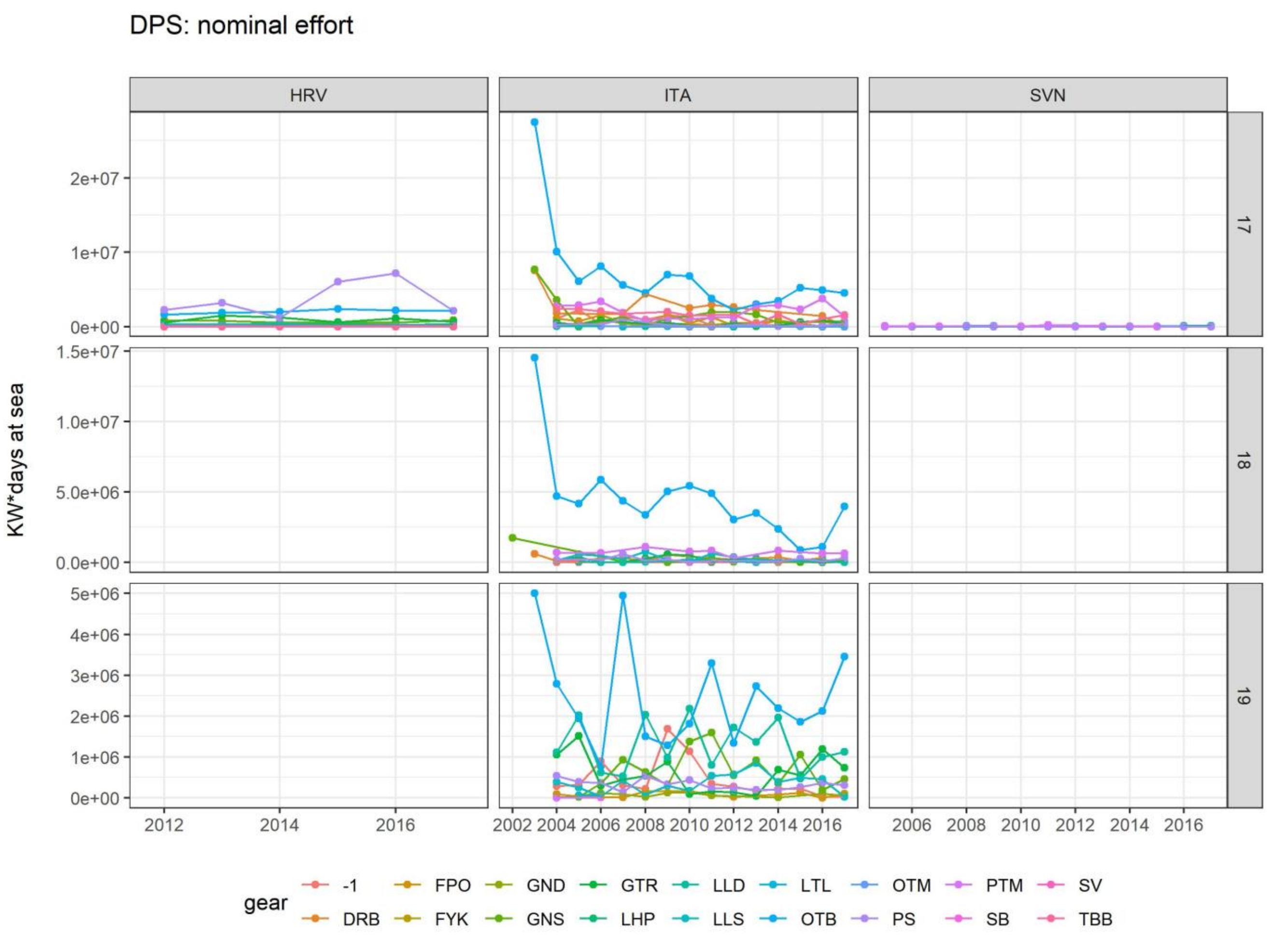


Figure 6.4.2.2.1. **Deep-water rose shrimp in GSA 17-19.** Nominal effort by fleet, year, country and area.

Nominal effort by fleet that report catches of some DPS is almost exclusively related to bottom trawl gears. Table 6.4.2.2.1 show effort values from OTB by country and gsa (Figure 6.4.2.2.2) and for the whole area (Figure 6.4.2.2.2).

Table 6.4.2.2.1. Deep-water rose shrimp in GSA 17-19. Fishing effort in nominal effort, GT*Days at sea and Days at sea by year and fishing gear.

gsa	country	gear	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
17	HRV	OTB	0	0	0	0	0	0	0	0	0	1630587	1859634	1984391	2389646	2181732	2123555
17	ITA	OTB	27486393	10071569	6081576	8136671	5598424	4522733	6997610	6776081	3768980	2267947	3017774	3423905	5238809	4917122	4497771
17	SVN	OTB	0	0	36869.4	27457	41472.8	127226.5	107464.8	58005.88	112440.9	47885.6	12023	7638	51341.7	30268.4	27445.3
18	ITA	OTB	14530793	4709285	4159165	5850066	4351301	3345982	5017395	5419689	4902562	3043563	3482955	2372921	874759	1085514	3946224
19	ITA	OTB	5002396	2787749	1945416	772266	4942437	1505117	1281958	1816764	3290819	1344209	2733581	2194448	1863294	2128423	3452780
all	all	OTB	47019582	17568603	12223026	14786460	14933635	9501059	13404428	14070540	12074802	8334191	11105967	9983303.2	10417850	10343060	14047775

Figure 6.4.2.3. **Deep-water rose shrimp in GSA 17-19.** Nominal effort by OTB and year in the three GSAs.

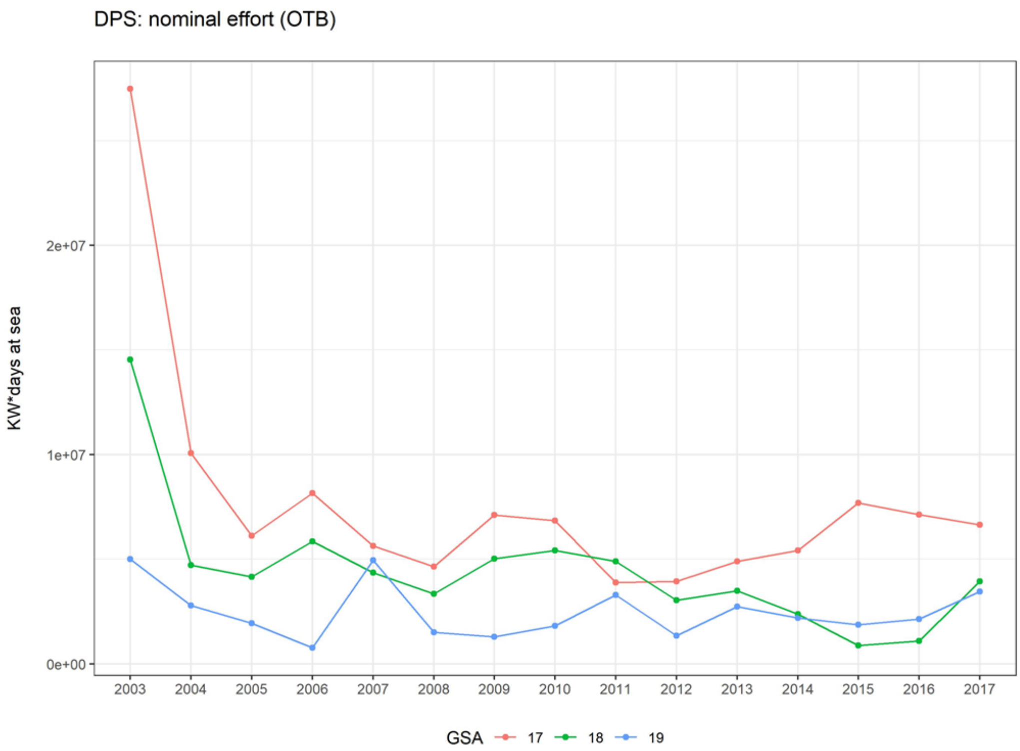


Figure 6.4.2.3. **Deep-water rose shrimp in GSA 17-19.**: Nominal effort by OTB and year in the three GSAs.

6.4.2.3 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out each year during the spring season in GSAs 17-19 (Figure 6.4.2.3.1) and MEDITS was conducted consistently from 2007 to the present.

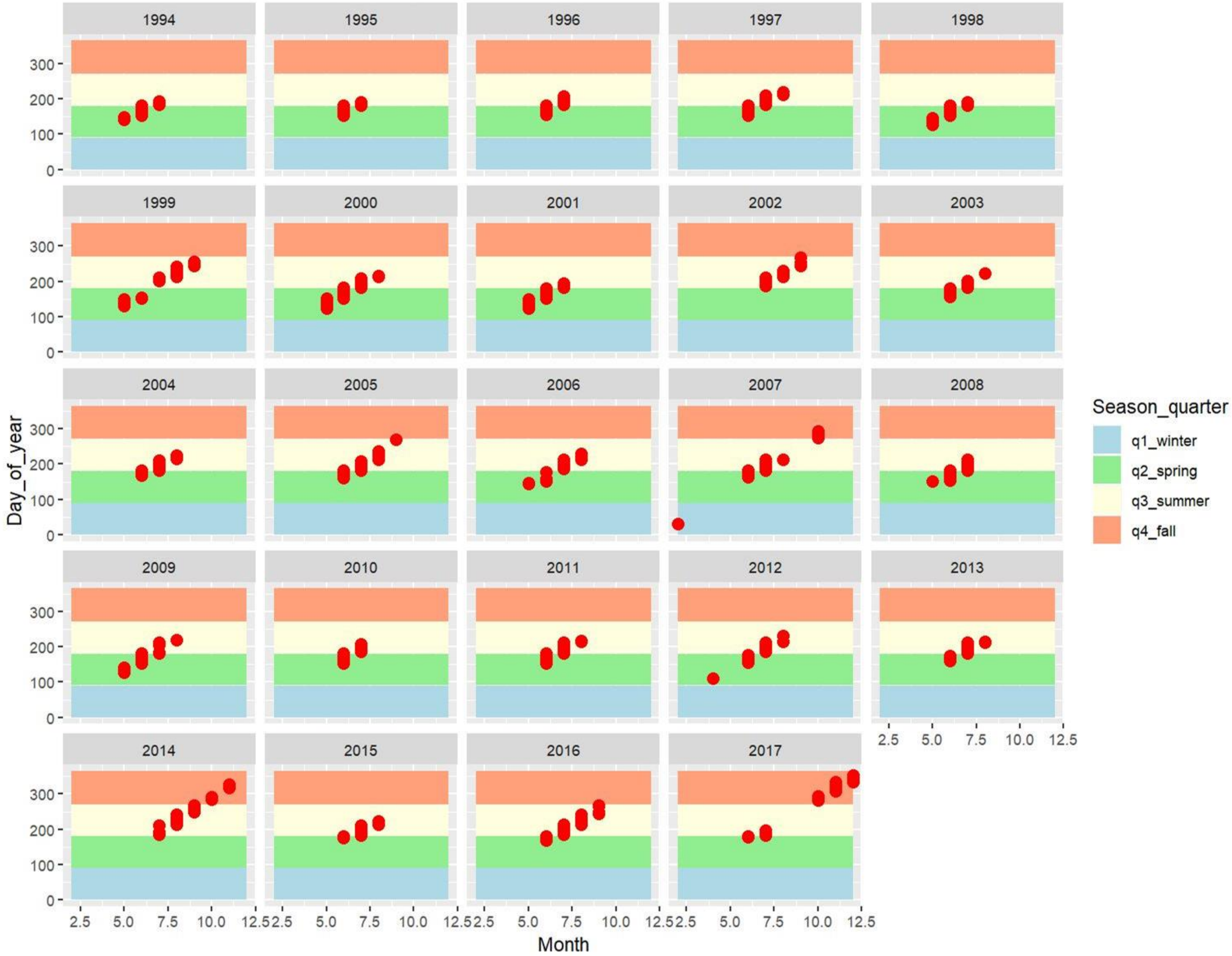


Figure 6.4.2.3.1. **Deep-water rose shrimp in GSA 17-19.** Period of MEDITS survey in GSAs 17-18-19.

Table 6.4.2.3.1. Deep-water rose shrimp in GSA 17-19. Total number of MEDITS hauls per year and country.

country	HRV	ITA	ITA	ITA	SVN
area	17	17	18	19	17
1994	0	86	72	73	0
1995	0	86	72	74	0
1996	0	85	112	74	2
1997	0	86	112	74	2
1998	0	86	112	74	2
1999	0	84	112	74	2
2000	0	86	112	74	2
2001	0	86	112	74	2
2002	59	119	90	70	2
2003	59	120	90	70	2
2004	61	118	90	70	2
2005	59	121	90	70	2
2006	59	120	90	70	0
2007	60	120	90	70	4
2008	59	121	90	70	2
2009	60	121	90	70	2
2010	60	120	90	70	2
2011	60	120	90	70	2
2012	60	119	90	70	2
2013	59	180	90	70	2
2014	56	180	90	70	2
2015	65	180	90	70	2
2016	56	180	90	70	2
2017	61	122	68	70	2

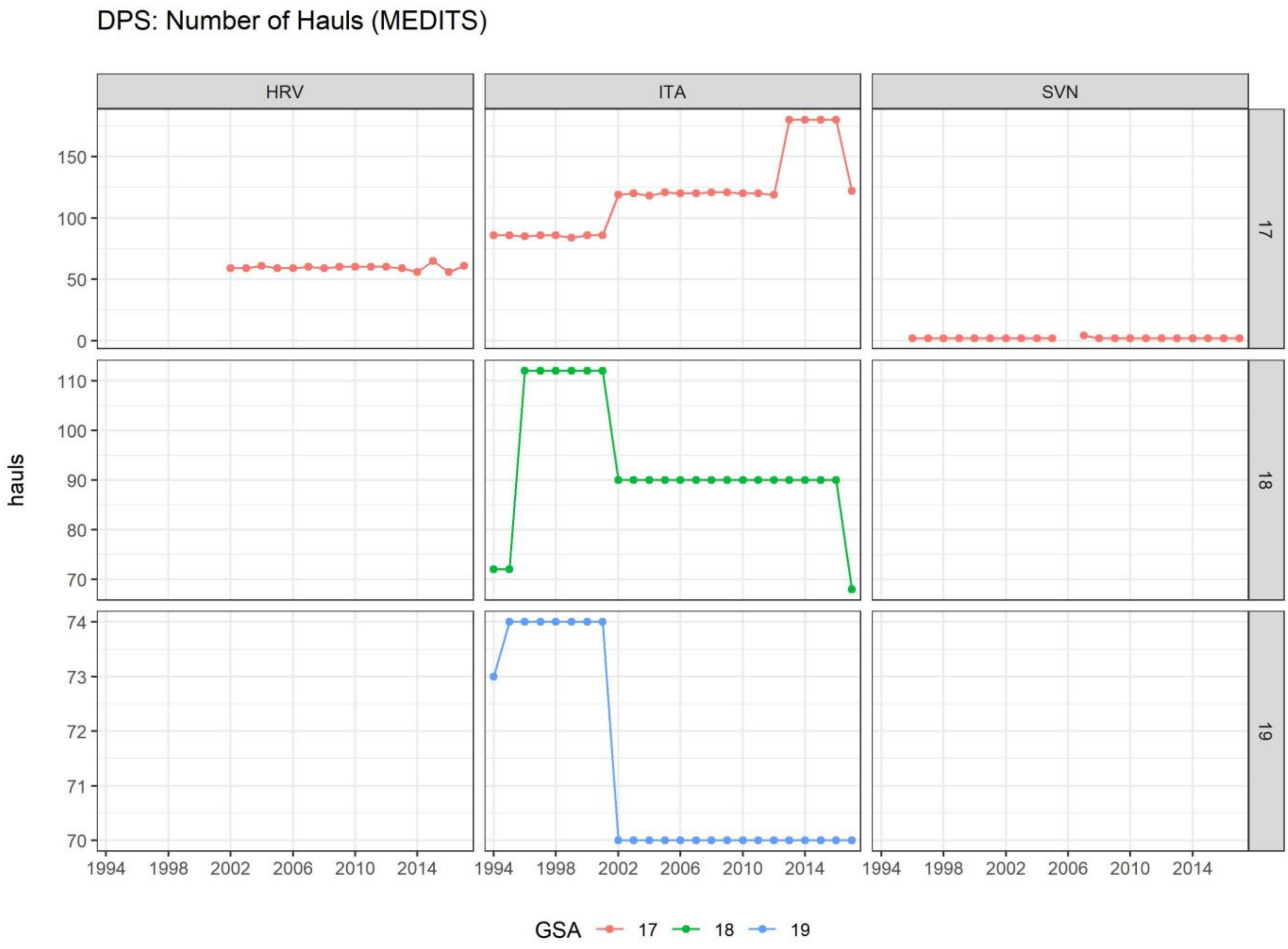


Figure 6.4.2.3.2. Deep-water rose shrimp in GSA 17-19. Total number of MEDITS hauls per year and country.

Observed abundance and biomass indices of Deep-water rose shrimp stocks from Medist are given in the figure 6.4.2.3.3).

Both estimated abundance and biomass indices show similar trends, with very high increas of value in last two years.

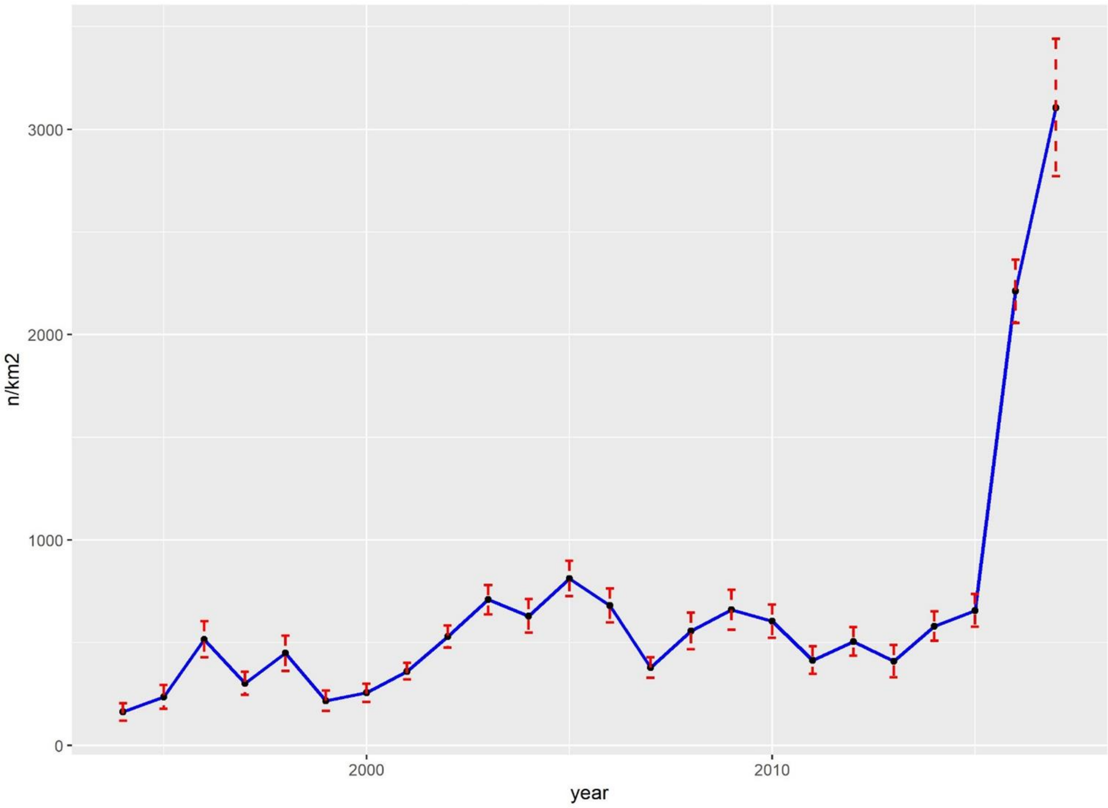


Figure 6.4.2.3.3. Deep-water rose shrimp in GSA 17-19. Estimated abundance indices (N/km^2).

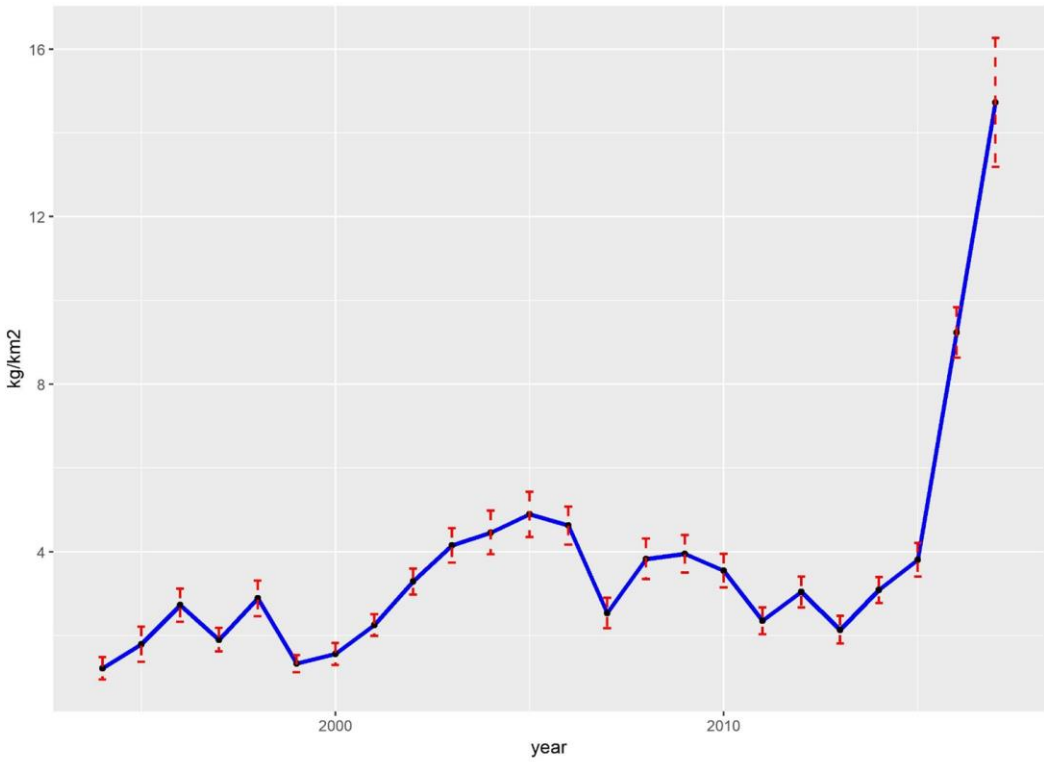


Figure 6.4.2.3.4. Deep-water rose shrimp in GSA 17-19. Estimated biomass indices (kg/km^2)

Length frequency distribution of Deep-water rose shrimp stocks from Medist are given in the figure below (Figure 6.4.2.3.3-5).

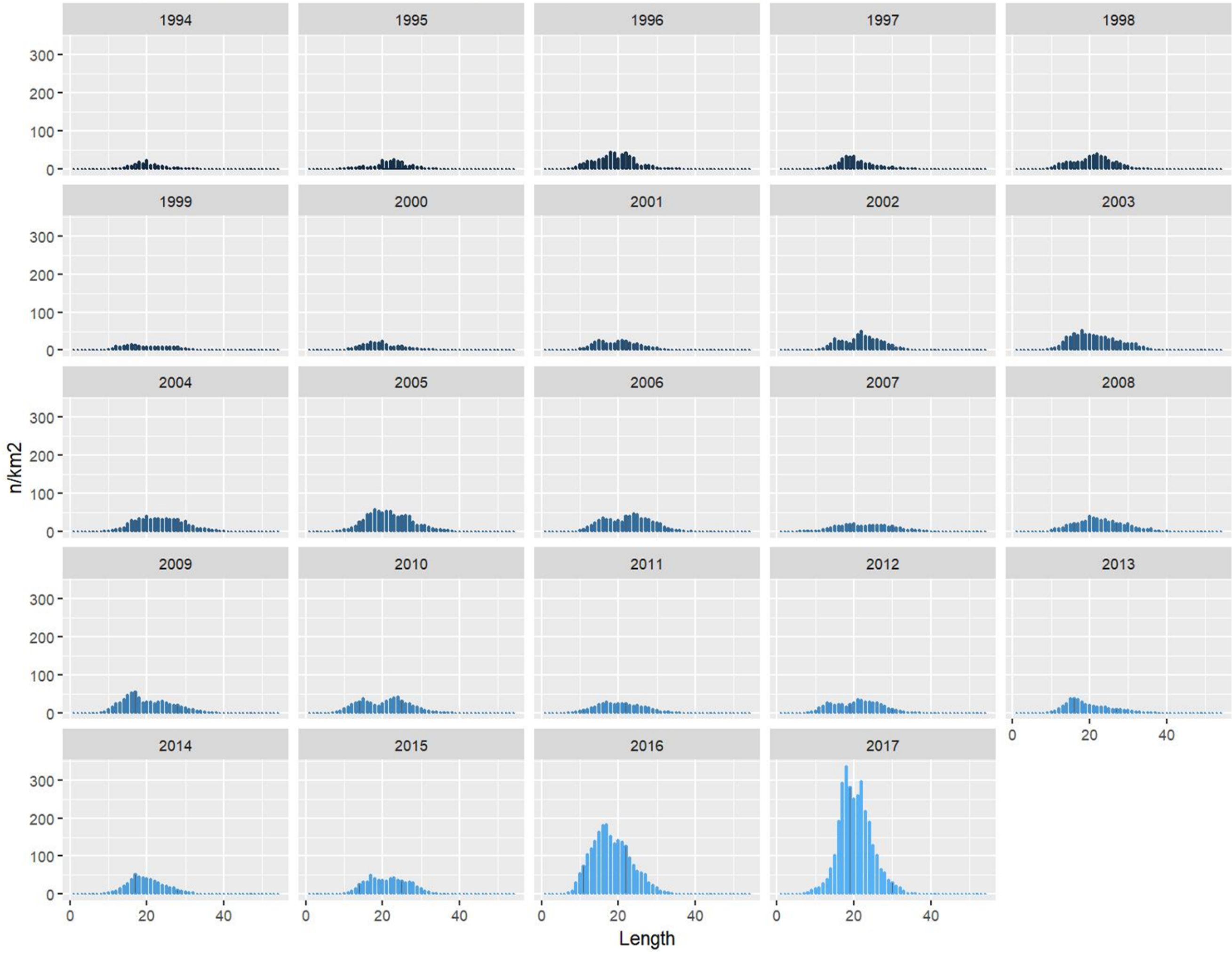


Figure 6.4.2.3.5. Deep-water rose shrimp in GSA 17-19. Length frequency distribution by year of MEDITS.

The conclusion to the data investigation, is that only age disaggregated data is available from 2002 for the catch, so the assessment is run based on catches from 2002 to 2017. In addition data on discards at length are available only from 2009 and thus were reconstructed after the slicing procedure by by multiplying for the missing years the numbers of age at landings for the average ratio of discards and landings in the time series.

6.4.3 Stock assessment

The statistical catch-at-age method Assessment for All (a4a) (Jardim et al., 2015) was used to estimate historical population size and fishing mortality.

Using the l2a routine in FLR catch at length and MEDITS abundaces were deterministically length sliced to numbers and mean weights at age for the assessment using the growth parameters and weight length relationship given in Table 6.4.1.4. These parameters were taken from the DCF data call and considered reasonable.

Stock assessment input data for the a4a model are given in tables 6.4.3.1-6 and figures 6.4.3.1-4.

Input data

The catch age matrix from the slicing of MEDITS catch rate at length data is reported in Figure 6.4.3.1 and Table 6.4.3.1.

Table 6.4.3.1. Deep-water rose shrimp stocks in GSAs 17-19: MEDITS tuning index of abundance by age and by year.

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	40.1	84.5	36.7	70.2	66.9	41.9	52.9	124.9	120.1	64.5	99.5	70.5	64.7	61.8	544.0	192.3
1	424.2	518.3	459.5	640.2	497.7	244.5	392.8	465.5	421.7	316.0	362.0	303.6	460.3	530.6	1597.2	2781.5
2	53.5	96.2	110.4	88.6	104.4	70.0	90.2	64.3	54.3	32.2	41.3	33.1	31.1	61.5	67.9	125.7
3	2.5	9.4	22.5	13.1	11.5	17.1	20.1	5.4	4.4	1.4	2.0	2.8	1.6	2.4	1.3	5.8

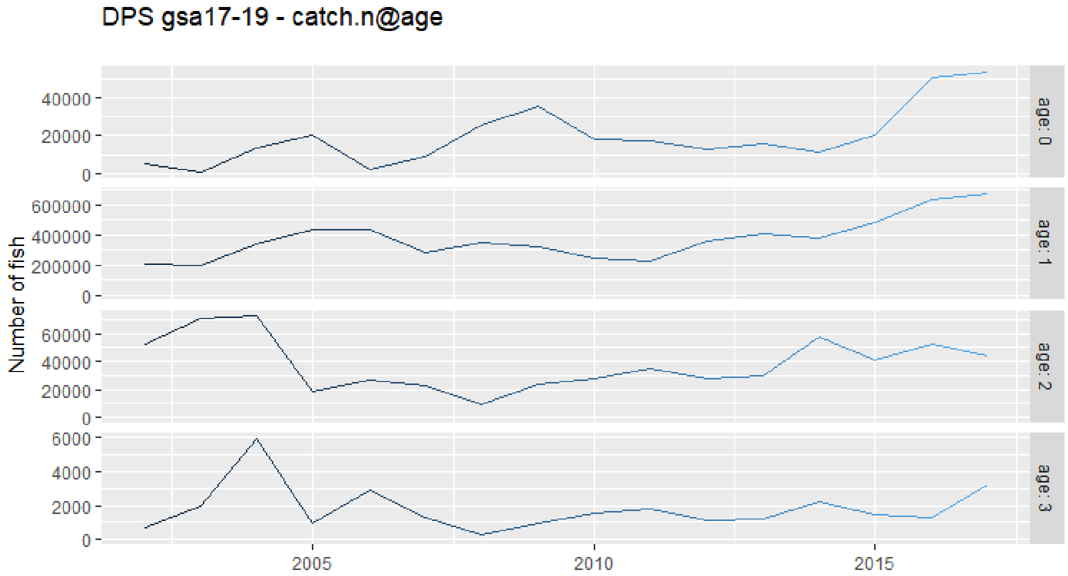


Figure 6.4.3.1. Deep-water rose shrimp in GSA 17-19. MEDITS mean catch/rate at age by year derived from length by slicing.

The catch at age from deterministically length sliced to numbers is reported in table 6.4.3.2.

Table 6.4.3.2. Deep-water rose shrimp in GSA 17-19. Catch at age by year (sum of landings + discards after slicing).

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	4183	298	12705	17477	655	6124	9563	26433	14680	12627	4771	6035	6891	13033	35339	40689
1	166644	151596	320900	370576	176510	195693	130561	240280	198046	168589	132935	156592	232490	307434	438363	504583
2	41370	55305	68118	16260	10646	15764	3655	17736	22684	25694	10203	11415	35028	26318	36455	33478
3	560	1528	5555	821	1167	892	120	683	1250	1325	418	481	1378	947	906	2408

Differences on total catch and total of catch at age were checked and the sum of products correction (SOP) was needed.

The catches at age was raised to the total catch by applying the SOP (figure 6.4.3.2). The corrected catch at age matrix and the applied SOP factors are reported below on tables 6.4.3.3 and 6.4.3.4 respectively. The SOP factors represent not just numercial issues but include also the extent of 'fill-ins' where no sampling data is provided, but similar fleets have sampling data.

Table 6.4.3.3. Deep-water rose shrimp in GSA 17-19. The new catch at age matrix SOP corrected.

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	5287	382	13569	20372	1630	8949	25610	35382	18048	16995	12791	15535	11253	20429	51116	54351
1	210617	194091	342715	431968	439382	285957	349647	321624	243477	226908	356371	403086	379629	481879	634060	674006
2	52287	70808	72748	18953	26501	23035	9789	23740	27887	34582	27353	29384	57197	41251	52729	44719
3	708	1956	5933	957	2905	1303	321	914	1537	1783	1120	1238	2250	1485	1310	3217

Table 6.4.3.4. Deep-water rose shrimp in GSA 17-19. SOP corrections for years applied to raised catch at length/age used in the assessment.(SOP values include 'fill-ins' as well as numerical corrections)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
SOP	1.26	1.28	1.07	1.17	2.49	1.46	2.68	1.34	1.23	1.35	2.68	2.57	1.63	1.57	1.45	1.34

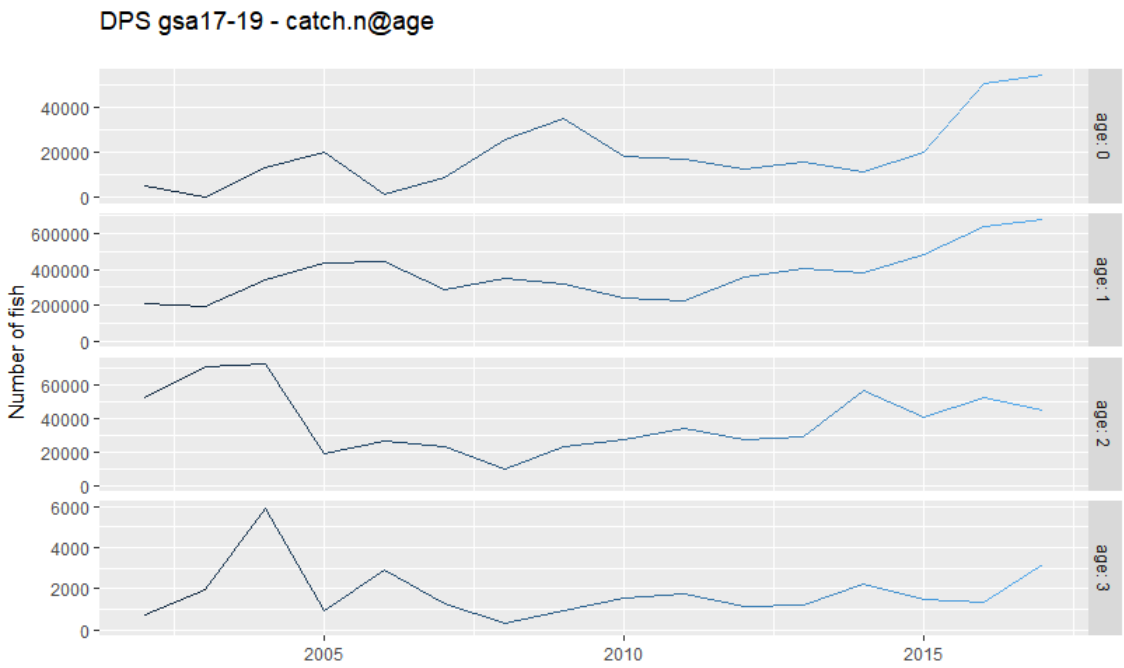
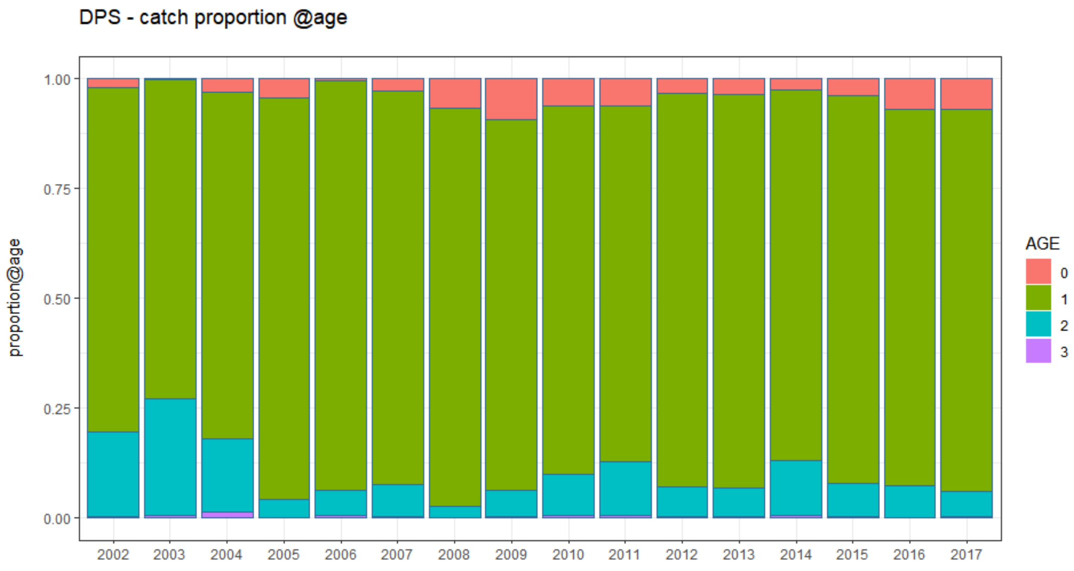
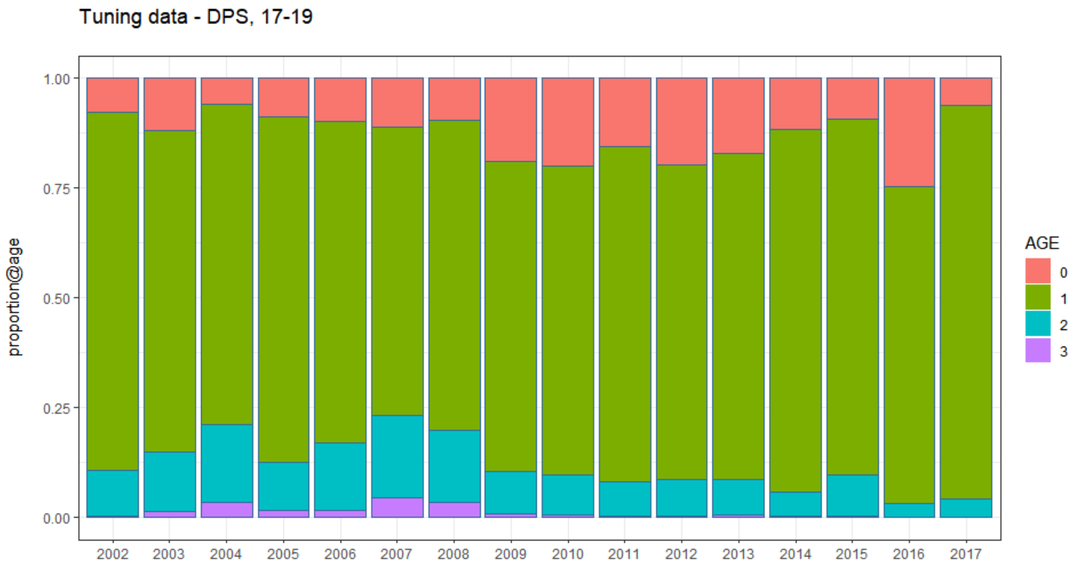


Figure 6.4.3.2. Deep-water rose shrimp in GSA 17-19. Catch at age by year from length slicing and SOP correction.

The proportion of catch at age both for catch and tuning fleet are reported below (Figure 6.4.3.3).



a



b

Figure 6.4.3.3. Deep-water rose shrimp in GSA 17-19. Proportion at age by year from catch at length (a) and index at length (b) slicing.

The catches shows in the assessment is shown in Figure 6.4.3.4 and Table 6.4.3.5,with an increasing trend over the last 7 years.

Table 6.4.3.5. Deep-water rose shrimp in GSA 17-19. Total Catch by year in tonnes

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
all	2144	2406	3554	2951	3212	2074	2074	2290	1942	1965	2445	2744	3129	3472	4517	4834

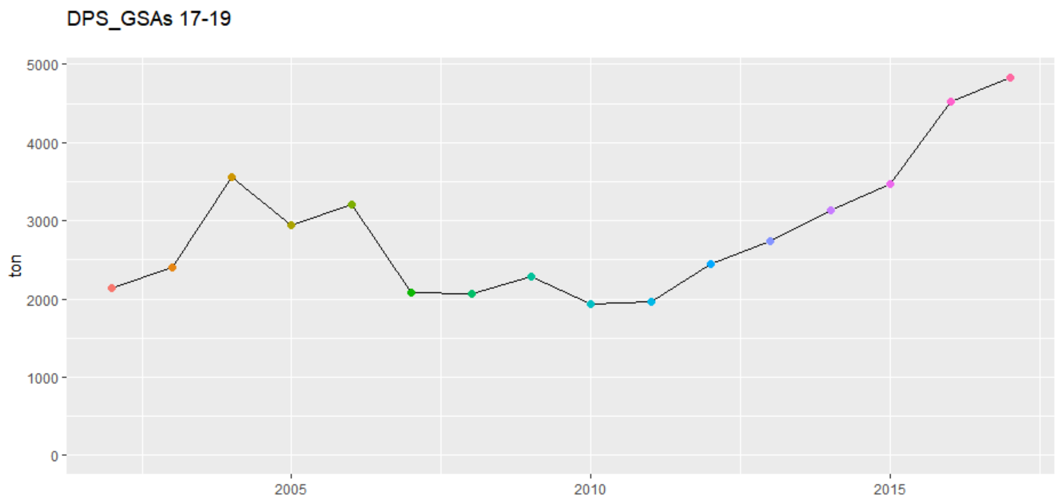


Figure 6.4.3.4. Deep-water rose shrimp in GSA 17-19. Trend of total catch in tonnes used as input in the assessment.

The iInput data on maturity, natural Mortality derived by the Chan-Watanabe method, and catch weights at age used in the assessment are reported on table 6.4.3.6.

Table 6.4.3.6. Deep-water rose shrimp in GSA 17-19. Maturity and Natural mortality and catch weights at age.

Age	0	1	2	3
Maturity	0.519	0.939	0.977	1.0
Natural Mortality	0.466	0.353	0.291	0.252
weights at age (kg)	0.002	0.007	0.014	0.024

Average spawning time was set 0.5 (1st July) according to the biology of the species.

Catch were used from 2002 to 2017.

The age age range used in the assessment was 0 to 3+.

Fbar was set from 1 to 2.

The stock assessment was based on the following submodels:

fmodel: ~factor(replace(age, age > 1, 1)) + s(year, k = 6) + s(age, k = 2, by = breakpts(year, 2010)) (separable model with smoothing for year and breakpoint in 2010)

srmodel: ~factor(year) (recruitment independent by year)

n1model: ~factor(age)

qmodel: **~factor(age)**

vmodel: **catch: ~s(age, k = 3) (smooth catch model)**

IND: **~1 (One index)**

Assessment results (method a4a)

Deep-water rose shrimp stocks in GSAs 17-19: Assessment results are shown in figures 6.4.3.5 to 6.4.3.3.12 and given in Table 6.4.3.7 to 6.4.3.9.

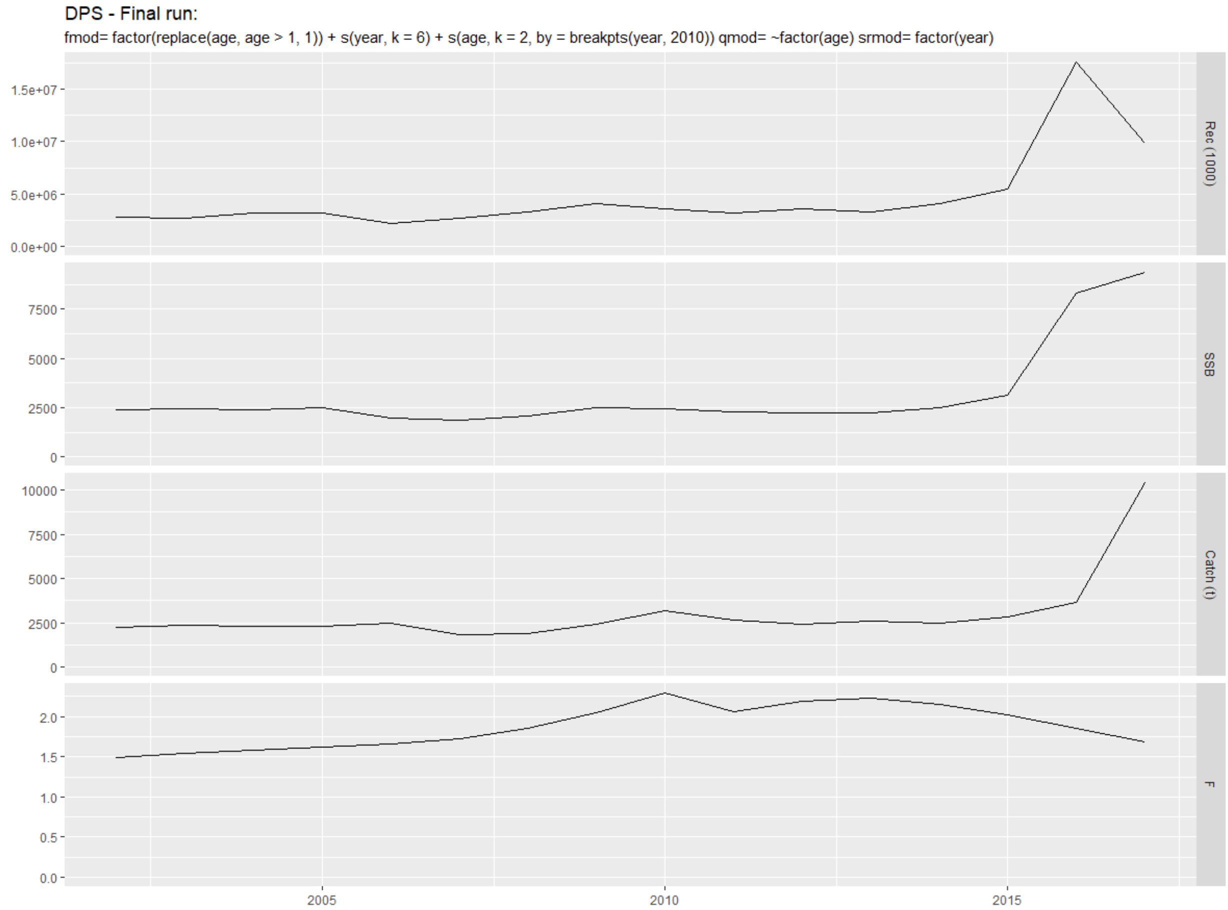


Figure 6.4.3.5. Deep-water rose shrimp in GSA 17-19. Stock summary from the a4a model for recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 2).

Table 6.4.3.7. **Deep-water rose shrimp in GSA 17-19.** Stock summary from the assessment.

year	Fbar 0-2	Recruitment	SSB	TB	Catch
2002	Fbar 1-2	2785160	2411	9289	2268
2003	1.49	2748991	2445	9615	2350
2004	1.54	3184531	2381	9444	2276
2005	1.59	3219191	2501	10074	2304
2006	1.62	2194468	1987	7718	2490
2007	1.65	2724979	1846	7630	1841
2008	1.72	3269371	2096	8974	1868
2009	1.85	4126159	2494	11060	2436
2010	2.04	3575085	2440	11238	3214
2011	2.29	3200568	2277	9776	2676
2012	2.06	3633111	2236	10002	2442
2013	2.19	3278316	2250	10039	2605
2014	2.23	4073328	2500	11106	2499
2015	2.15	5439999	3131	13575	2852
2016	2.02	17553416	8335	36900	3683
2017	1.85	9883771	9359	35754	10408

Table 6.4.3.8 Deep-water rose shrimp in GSA 17-19. Stock number by age and by year in thousands.

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	2785200	2749000	3184500	3219200	2194500	2725000	3269400	4126200	3575100	3200600	3633100	3278300	4073300	5440000	17553000	9883800
1	565490	481880	475540	550800	556740	379480	471110	564990	712600	616930	551830	626070	564850	702030	938100	3029000
2	38662	62914	51247	48729	54923	53852	34661	38670	39304	40254	48938	39401	43598	41546	57468	87203
3	857.62	3449.2	5682.7	4953.9	4471.9	4653	4291.5	2625.1	2096.1	1572.7	1603.7	1640.2	1281.9	1525.5	1734.9	2911.5

Table 6.4.3.9. **Deep-water rose shrimp in GSA 17-19.** Fishing Mortality by age and by year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1	1.26	1.3	1.34	1.37	1.4	1.45	1.56	1.73	1.94	1.6	1.7	1.73	1.67	1.56	1.44	1.31
2	1.72	1.78	1.83	1.87	1.91	1.99	2.14	2.36	2.65	2.52	2.68	2.72	2.64	2.47	2.27	2.07
3	0.93	0.97	0.99	1.01	1.04	1.08	1.16	1.28	1.44	2.46	2.62	2.66	2.58	2.41	2.22	2.02

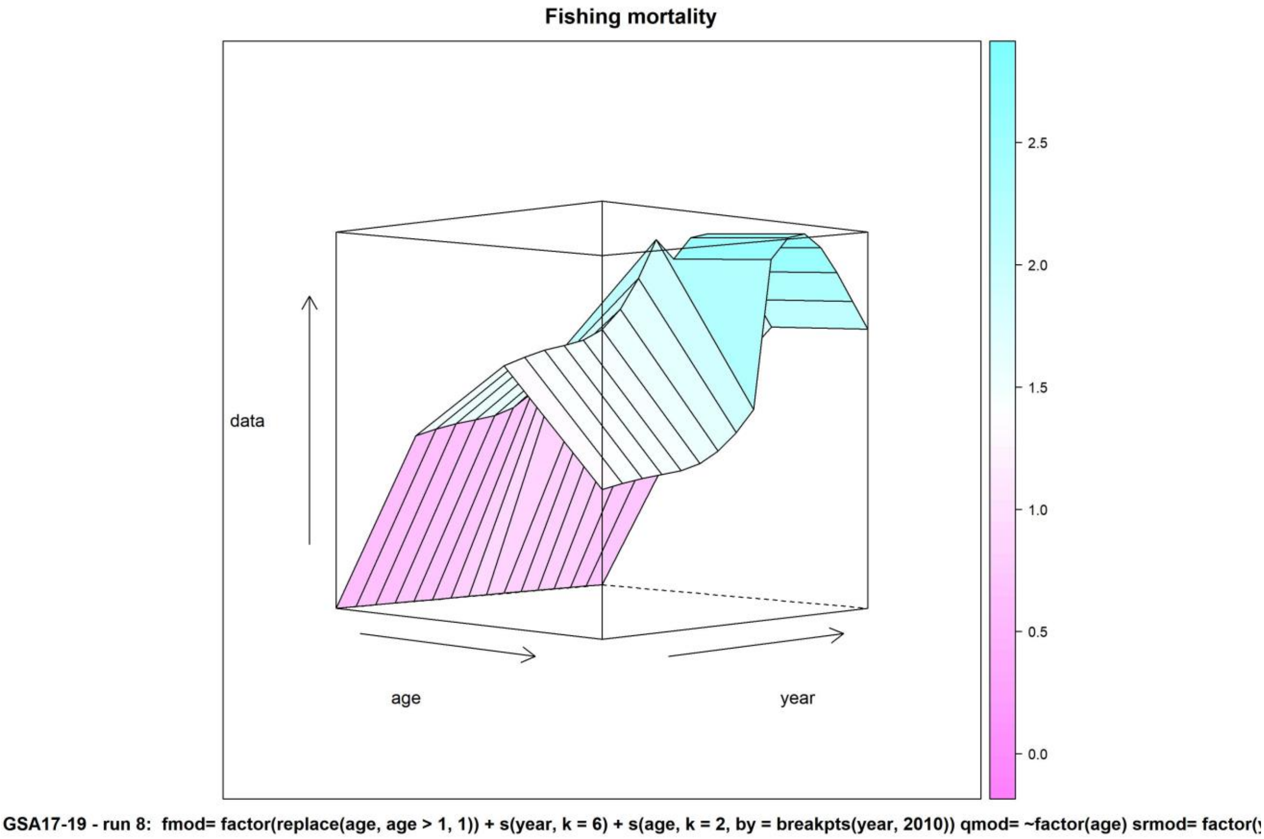


Figure 6.4.3.6. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated fishing mortality at age and year.

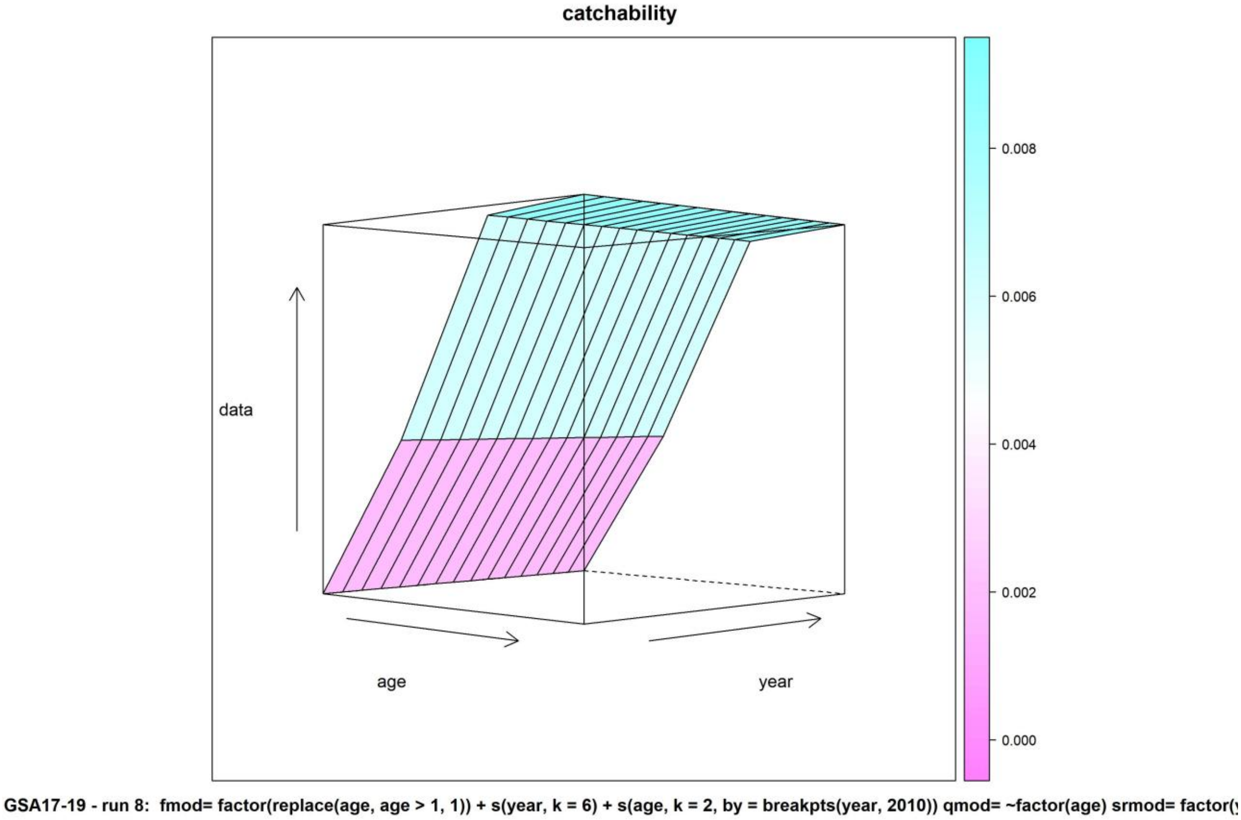


Figure 6.4.3.7. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated catchability at age and year.

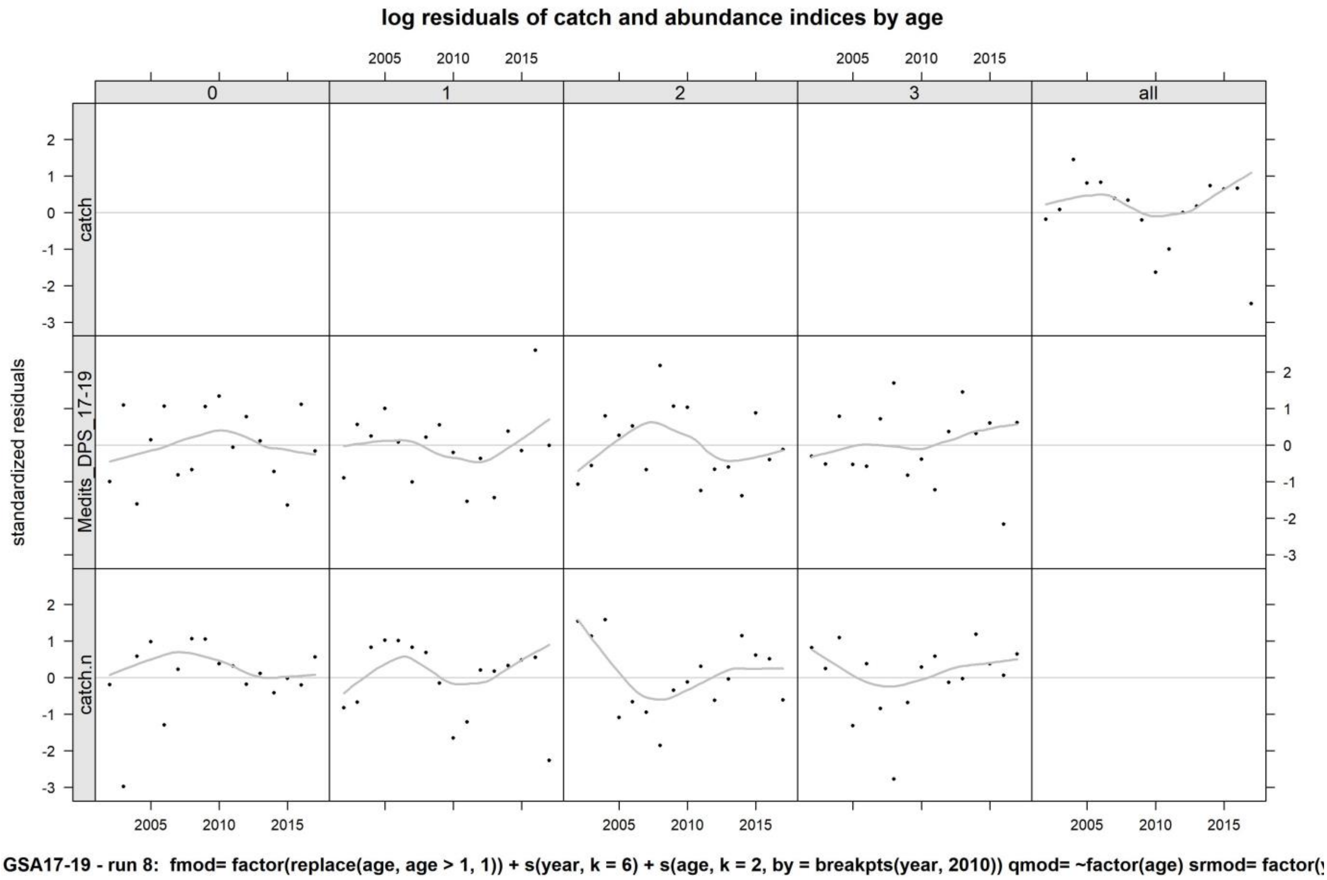


Figure 6.4.3.8. Deep-water rose shrimp stocks in GSAs 17-19. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

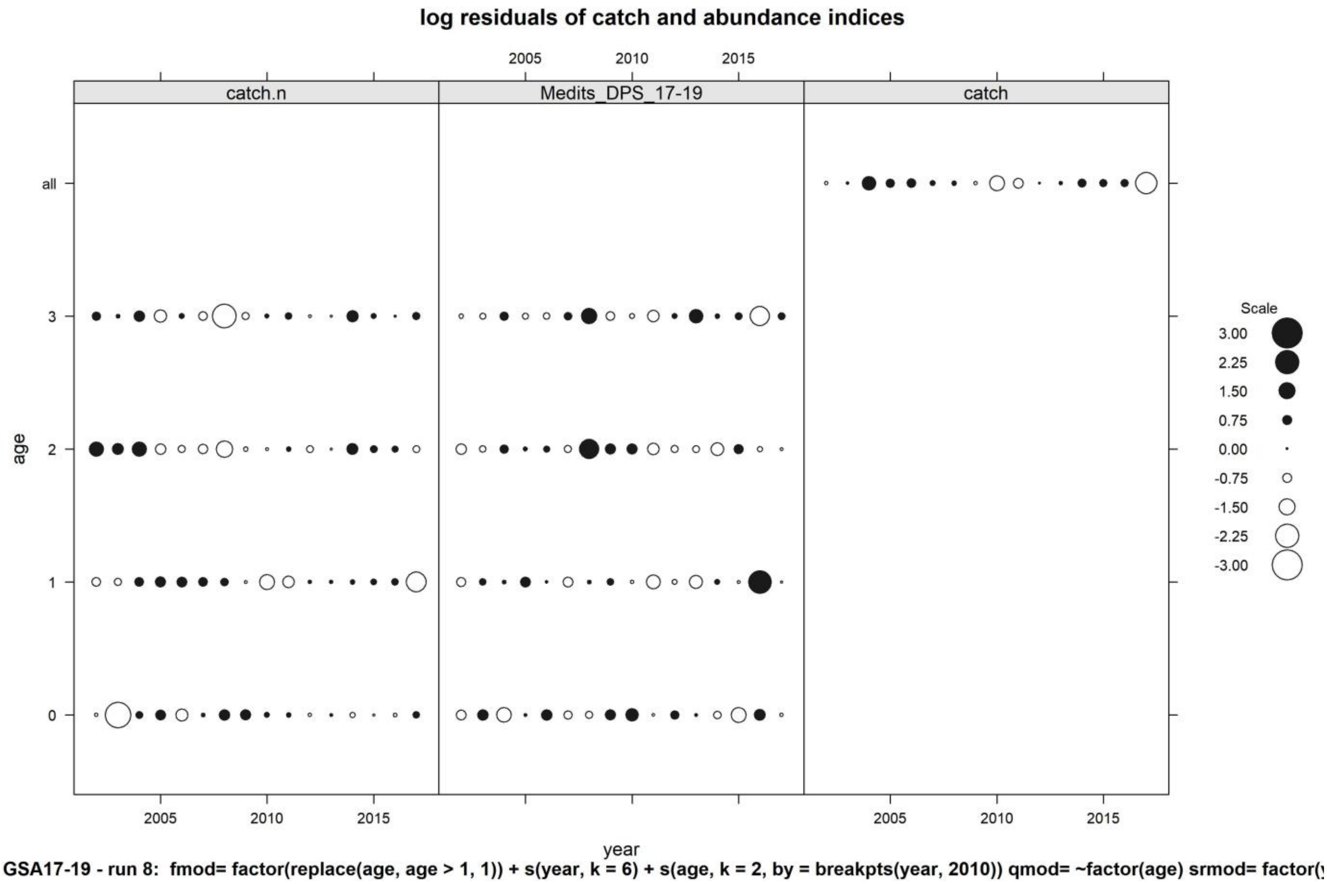


Figure 6.4.3.9. Deep-water rose shrimp stocks in GSAs 17-19. Residuals of residuals for abundance indices and catch by age.

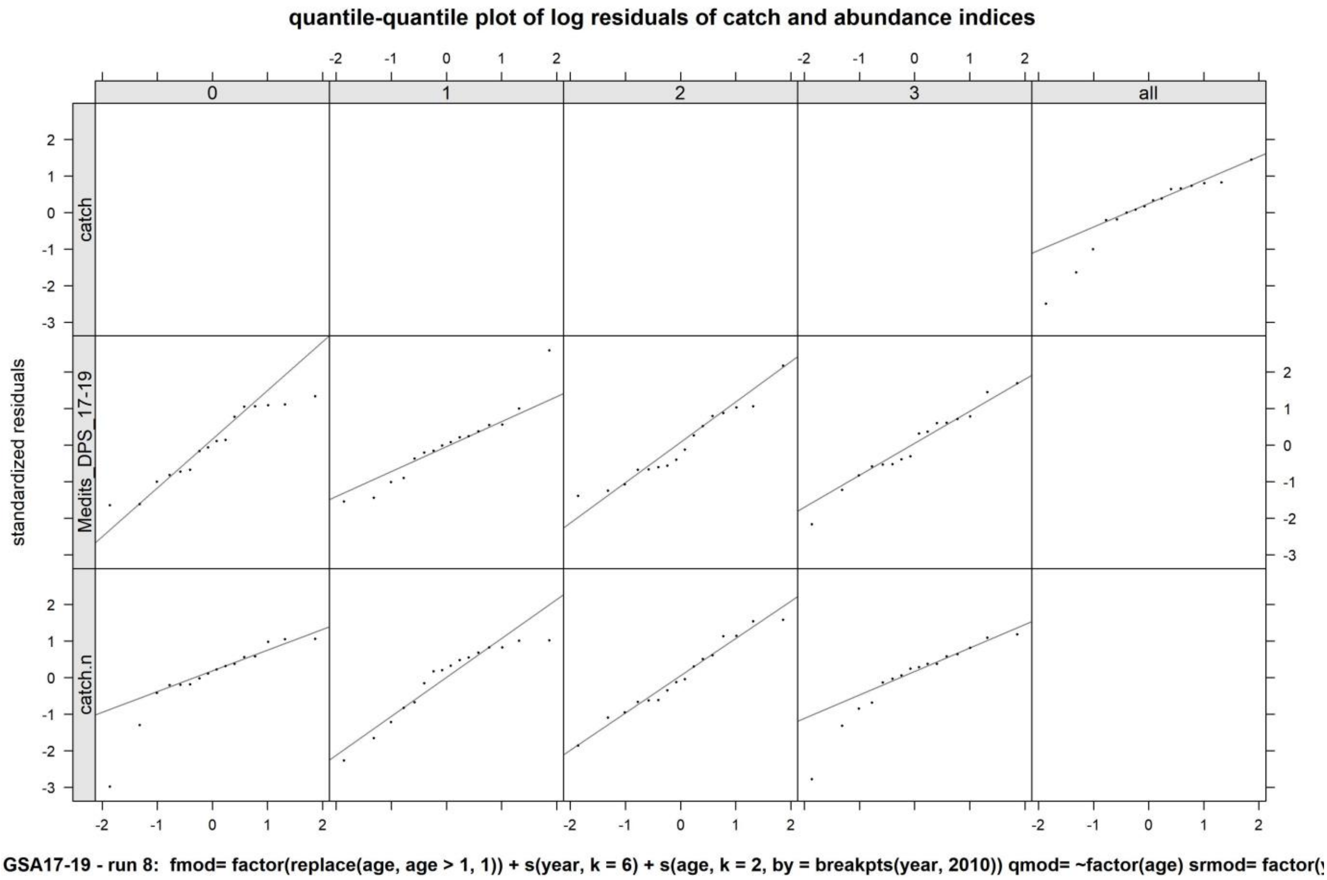


Figure 6.4.3.10. Deep-water rose shrimp stocks in GSAs 17-19. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

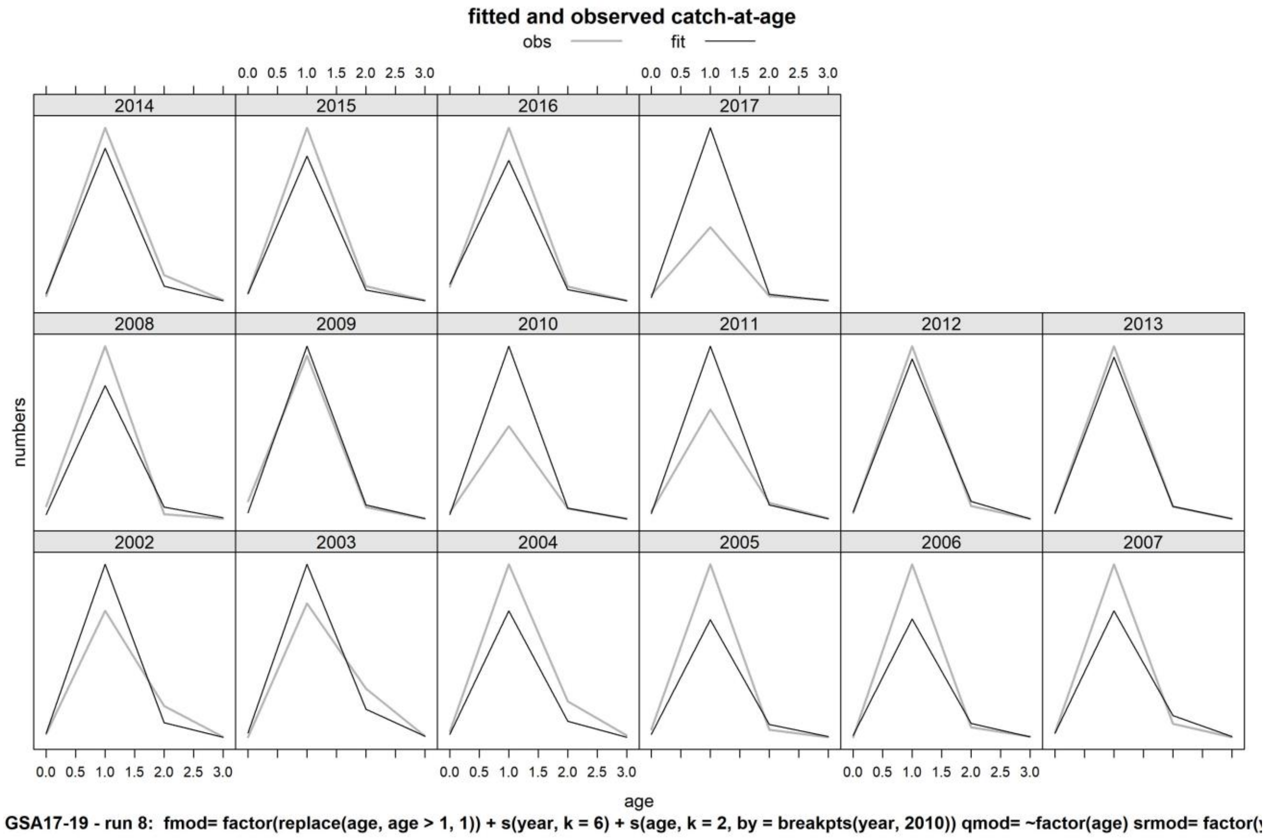


Figure 6.4.3.11. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed catch at age.

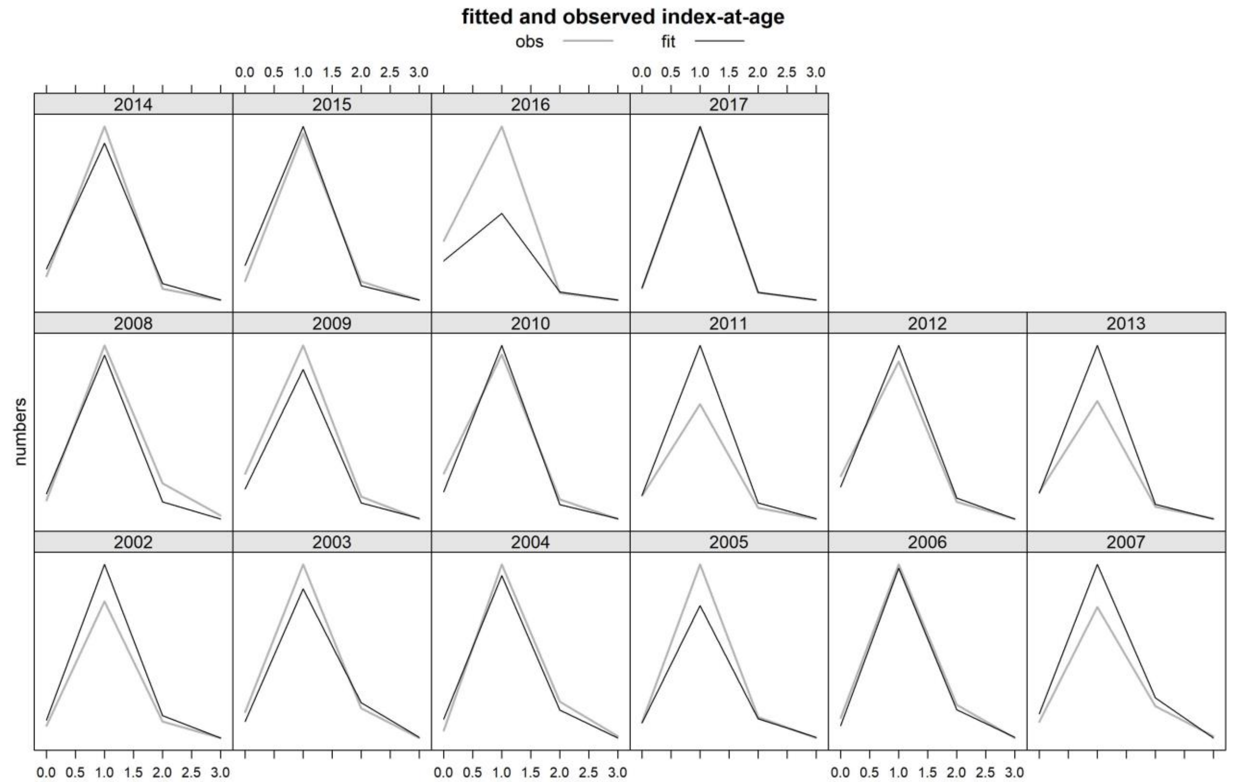


Figure 6.4.3.12. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed index at age.

Retrospective

The retrospective analysis applied up to 1 years back only due to the short time series shows quite moderate stability for the models (Figure 6.4.3.10), however, the conclusions on stock exploitation status of F>F0.1 is maintained throughtout.

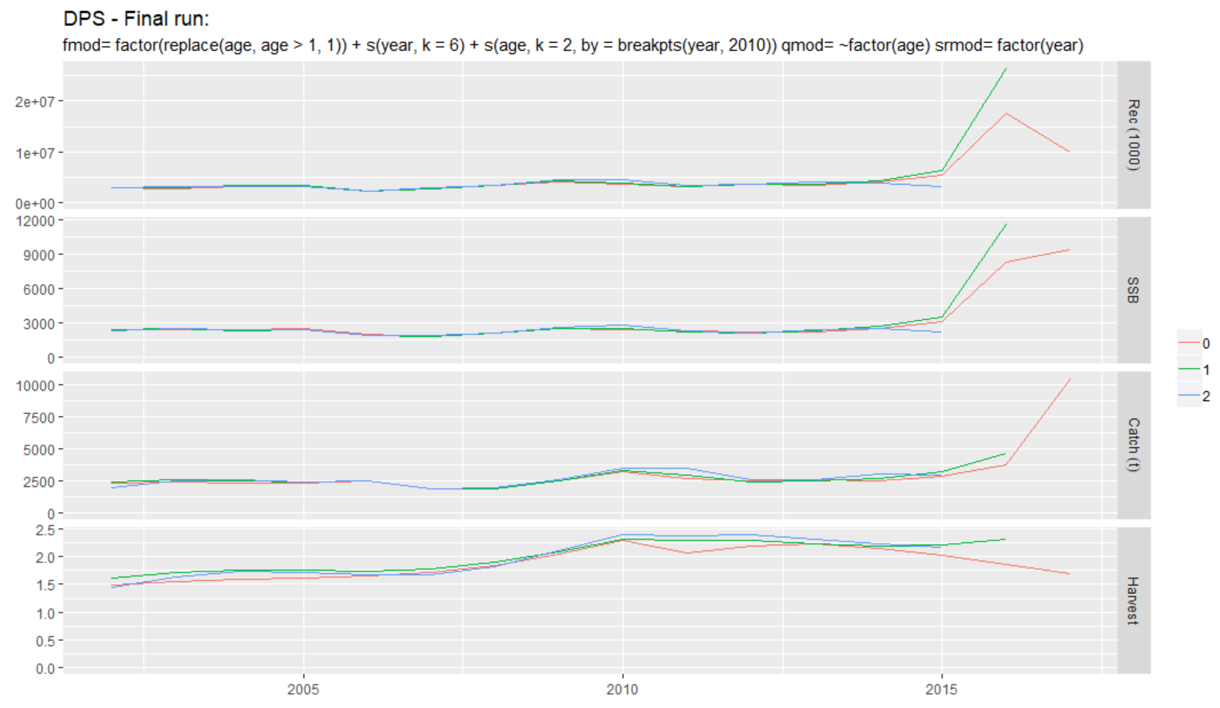


Figure 6.4.3.13. Deep-water rose shrimp in GSA 17-19. Analytical retrospective 2002 to 2017, Recruitment, SSB, catch and Fishing mortality.

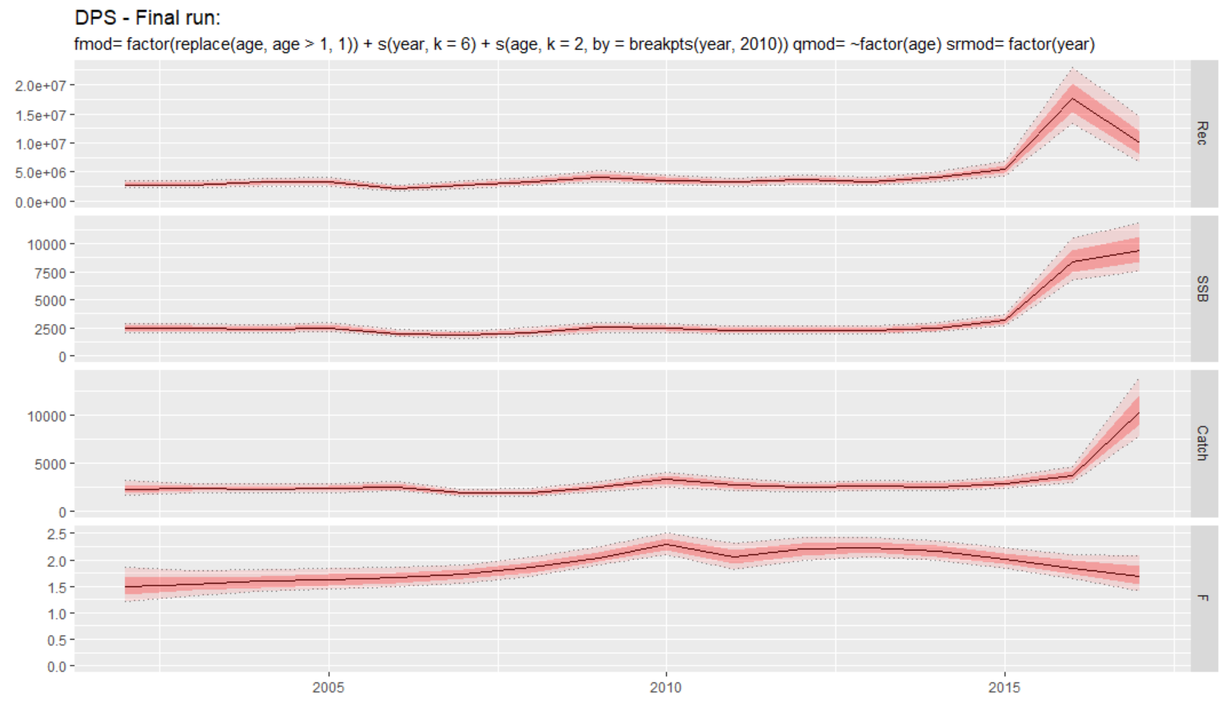


Figure 6.4.3.14. **Deep-water rose shrimp in GSA 17-19.** Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals 2002 to 2017.

Conclusions to the assessment

This assessment is considered acceptable, the age sliced index has coherence from year to year and the assessment provides a coherent explanation of the trend in catches. Retrospective performance is moderately stable and confirms stock explitation status throughout.

Based on the a4a results, the Deep-water rose shrimp stocks in GSAs 17-19 shows SSB an increase in the last two years (2016 and 2017) and a spike in the number of recruits in 2016 with the last year's recruitment (2017) the second highest in the series with a value of 9883 thousands individuals. Fbar (1-2) fluctuated and shows a decreasing trend in the last years down to a value of 1.67 in 2017. The assessment has considerable difficulty in estimating catch in 2017. The rapidly changing recruitment over the last few years results in the assessment estimating higher than reported catches by a factor close to two. If this is incorrect, and catches are nearer reported catch, then F in the final year will be lower than the F shown in the assessment. However, F will still be above F_{msy}.

6.4.4 REFERENCE POINTS

Based on input data the reference points are given in Table 6.4.4.1

Table 6.4.4.1 Deep-water rose shrimp stocks in GSAs 17-19. reference points.

refpt	harvest	yield	rec	ssb	biomass
f0.1	0.65	0.00062	1	0.0013	0.0016

6.4.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term forecast was carried using FLSTF for years 2018 to 2020.

For mean weights, maturity, natural mortality and selection pattern, the last year was used. The recruitment in 2018 to 2020 (5186919 thousand)was taken as geometric mean of the last seven years (2010-2017).

Fishing at F0.1 in 2019 leads to reduce catch of about 53% (Table 6.4.5.1).

Table 6.4.5.1. Deep-water rose shrimp stocks in GSAs 17-19: Short term forecast results for 2017 to 2020 based on selection and biological parameters of last years, and geometric mean recruitment from 2002 to 2017.

Rationale	Ffactor	Fbar	Catch_2017	Catch_2019	Catch_2020	SSB_2020	SSB_change 2018-2020(%)	Catch_change 2018-2019(%)
zero catch	0.0	0.00	10408	0.0	0.0	9910.9	64.1	-100
F01	0.4	0.65	10408	2635.0	3048.3	6124.2	1.4	-75
Fupp	0.5	0.89	10408	3294.5	3425.1	5365.4	-11.2	-68
Flow	0.3	0.43	10408	1903.4	2466.3	7054.8	16.8	-82
Status quo	1.0	1.69	10408	4847.87	3888.88	3866.3	-36.0	-53
Different scenarios	0.2	0.34	10408	1545.1	2111.8	7544.7	24.9	-85
	0.3	0.51	10408	2169.3	2699.2	6705.8	11.0	-79
	0.4	0.68	10408	2713.9	3100.4	6029.4	-0.2	-74
	0.5	0.85	10408	3190.6	3374.2	5480.0	-9.3	-69
	0.6	1.01	10408	3609.0	3561.4	5029.9	-16.7	-65
	0.7	1.18	10408	3977.5	3690.0	4658.2	-22.9	-62
	0.8	1.35	10408	4303.0	3779.4	4348.3	-28.0	-59
	0.9	1.52	10408	4591.4	3842.6	4087.6	-32.3	-56
	1.0	1.69	10408	4847.9	3888.9	3866.3	-36.0	-53
	1.1	1.86	10408	5076.6	3924.2	3676.7	-39.1	-51
	1.2	2.03	10408	5281.2	3952.7	3512.8	-41.8	-49
	1.3	2.20	10408	5464.9	3977.1	3369.9	-44.2	-47
	1.4	2.37	10408	5630.2	3999.1	3244.3	-46.3	-46
	1.5	2.54	10408	5779.5	4019.9	3133.1	-48.1	-44
	1.6	2.71	10408	5914.8	4040.2	3033.8	-49.8	-43
	1.7	2.87	10408	6037.7	4060.4	2944.8	-51.2	-42
	1.8	3.04	10408	6149.8	4080.7	2864.4	-52.6	-41
	1.9	3.21	10408	6252.2	4101.1	2791.4	-53.8	-40

	2.0	3.38	10408	6346.1	4121.7	2724.9	-54.9	-39

6.5 COMMON CUTTLEFISH IN GSA 17 AND 18

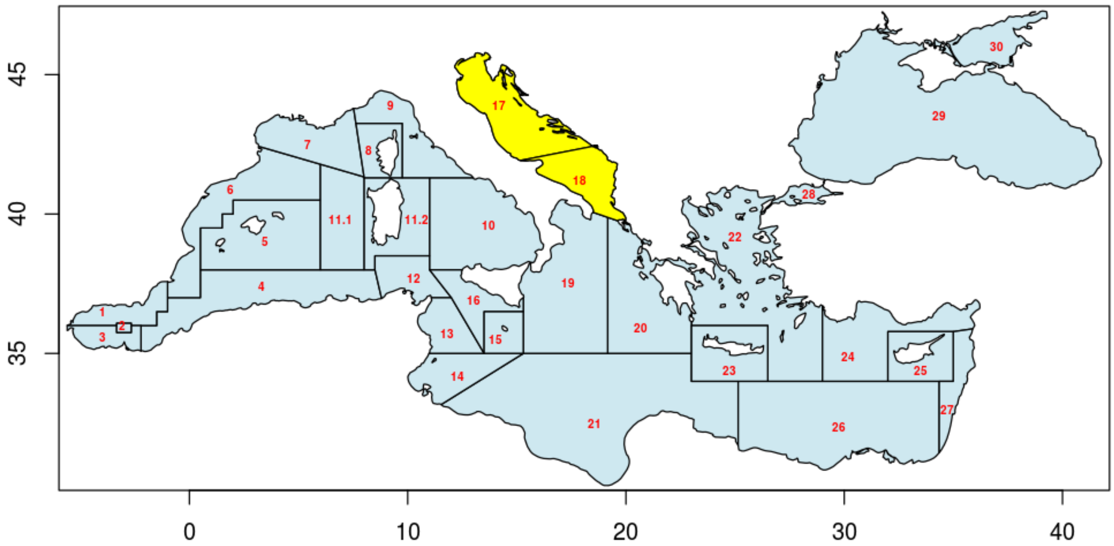


Figure 6.5.1.1 Geographical location of GSAs 17-18.

6.5.1 STOCK IDENTITY AND BIOLOGY

Common cuttlefish is found throughout the Mediterranean basin and the eastern Atlantic Ocean, from the Baltic Sea to about 17° N. It is a demersal species, more abundant in coastal waters on muddy and sandy bottoms covered with seaweed and phanerogams, but its distribution can be extended to a depth of about 200 m (Relini et al., 1999). In the Adriatic Sea (GSA 17-18) common cuttlefish (*Sepia officinalis*) inhabits the shelf zone at depths up to 200m, but MEDITS findings indicate that this species is mainly concentrated up to 100 m depth.

During the winter period, common cuttlefish resides mostly in circalitoral zone where it matures. In spring, it migrates to the shallower infralitoral region to spawn (Mandić, 1984). In the central and northern Adriatic Sea it occurs predominantly on sandy and muddy bottoms up to 100-150 m deep (Županović and Jardas, 1989). In the southern Adriatic, in the colder part of the year common cuttlefish is the most abundant at depths from 50 to 60 m. During the warmer part of the year, it migrates closer to the coast for spawning and forms dense settlements at 10 to 30 m depth (Mandić, 1984). The common cuttlefish is an active predator. It feeds mostly on crustaceans, especially decapods, but also fish. In the absence of this food, it can become cannibalistic (Fabi, 2001). According to Fisher et al. (1987) longevity of common cuttlefish is 18 to 30 months.

In the past, EWG 17-02 indicated that no evidence support existence of more than one single stock of common cuttlefish in the Adriatic Sea. In addition, EWG 18-16 analysed the most recent available geo-referenced spatial survey data (MEDITS data - period 2006-2016) from the Adriatic Sea, pointing out the continuity of common cuttlefish stock distribution along coasts of the Adriatic basin (Figure 6.5.1.2.).

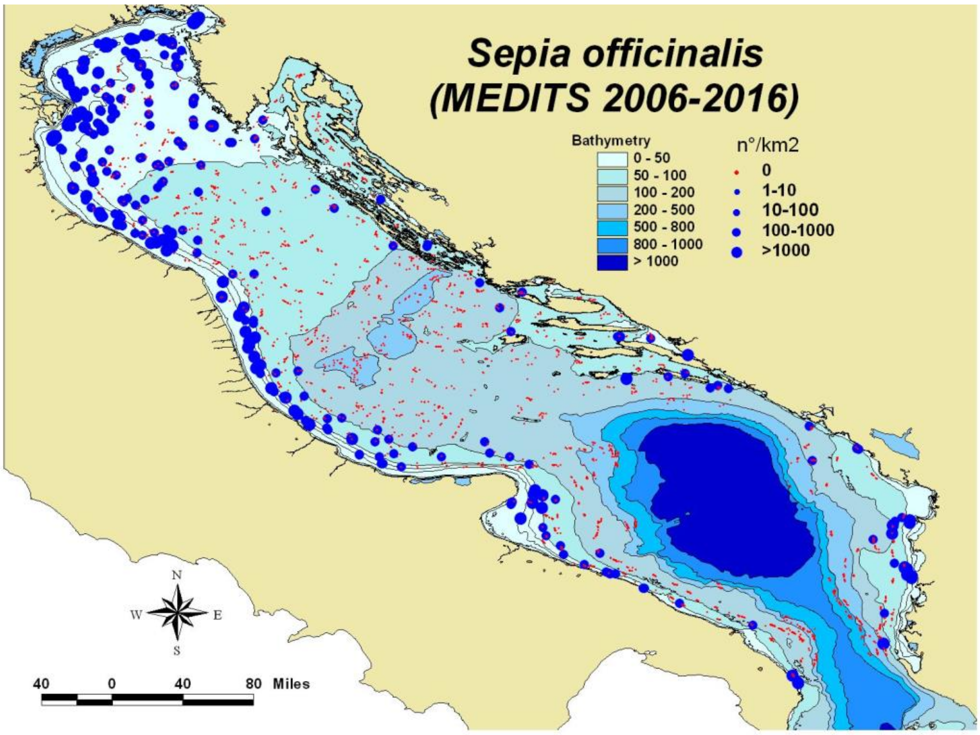


Figure 6.5.1.2 Common cuttlefish in GSA 17-18. Abundance indices in the Adriatic Sea as obtained from the most recent survey data (MEDITS, 2006-2016).

Natural mortality

Due to lack of growth parameters in DCF database, and use of CMSY and SPICT production model (this model has no need for natural mortality estimate) the natural mortality of common cuttlefish was not estimated by EWG 18-16.

Growth

The information on the age-length key (ALK) and on the growth von Bertalanffy parameters was not available for common cuttlefish in GSAs 17 and 18. The only Von Bertalanfy growth parameter for common cuttlefish in the Adriatic Sea available in DCF biological data is $ML_{infinity}$ reported by Slovenia (GSA17, period 2014-2016) is 16.6 cm. No other von Bertalanffy growth parameters are available in DCF data for GSAs 17 and 18.

Maximum size of common cuttlefish mantle length (ML) reported to DCF (landing table) is 29 cm (ITA, GSA17, 2015, FPO), while the maximum ML registered in MEDITS data in the Adriatic Sea was 21.5 cm.

All available DCF data on mantle length (ML, cm) – weight (g) relationship of common cuttlefish indicate negative alometric growth of this species in the Adriatic Sea.

Table 6.5.1.1 Common cuttlefish in GSA 17-18. Availability of growth parameters. (Source: DCF database)

Country	area	start_year	End year	sex	vb_linf	vb_k	vb_t0	vb_sample_size	vb_size_range (cm)	a	b	l_w_sample_size	l_w_size_range	l_w_units
SVN	SA 17	2014	2016	C	16.6	NA	NA	602	2.9-15.7	0.2182	2.757	1036	1.9-15.5	cm/g
ITA	SA 17	2016	2016	C	NA	NA	NA	NA	NA	0.2112	2.812	174	4-17	cm/g
ITA	SA 17	2016	2016	M	NA	NA	NA	NA	NA	0.2366	2.76	71	4-14	cm/g
ITA	SA 17	2016	2016	F	NA	NA	NA	NA	NA	0.2099	2.818	103	4-17	cm/g
ITA	SA 17	2013	2013	C	NA	NA	NA	NA	NA	0.1893	2.841	546	2-23	cm/g
ITA	SA 17	2013	2013	M	NA	NA	NA	NA	NA	0.2409	2.735	252	3-17	cm/g
ITA	SA 17	2013	2013	F	NA	NA	NA	NA	NA	0.1947	2.838	280	3-23	cm/g
ITA	SA 17	2012	2012	C	NA	NA	NA	NA	NA	0.2356	2.786	493	3-19	cm/g
ITA	SA 17	2012	2012	M	NA	NA	NA	NA	NA	0.2924	2.676	191	4-18	cm/g
ITA	SA 17	2012	2012	F	NA	NA	NA	NA	NA	0.2418	2.784	203	4-19	cm/g
ITA	SA 17	2011	2011	C	NA	NA	NA	NA	NA	0.3123	2.65	798	3-22	cm/g
ITA	SA 17	2011	2011	M	NA	NA	NA	NA	NA	0.399	2.536	311	3-22	cm/g
ITA	SA 17	2011	2011	F	NA	NA	NA	NA	NA	0.3084	2.668	391	3-20	cm/g
ITA	SA 17	2010	2010	C	NA	NA	NA	NA	NA	0.368	2.59	2050	3-19	cm/g
ITA	SA 17	2010	2010	M	NA	NA	NA	NA	NA	0.475	2.468	960	3-19	cm/g
ITA	SA 17	2010	2010	F	NA	NA	NA	NA	NA	0.353	2.613	1074	3-18	cm/g

* Source: DCF

Stock related biological variables are very scarce, and were not provided by Croatia, since exemption rules were applied for this species.

Maturity

Maturity data by length and/or age are not available in DCF database for common cuttlefish in GSAs 17 and 18.

However, according to published work of Manfrin Piccinetti and Giovanardi (1984) the length of the mantle at first sexual maturity of common cuttlefish in the Adriatic Sea is about 10 cm. The spawning period of this species extends throughout the year, with peaks in spring and summer. In the northern and central Adriatic, it reproduces in April and May, but females with mature eggs can be found even in June and July. In the southern Adriatic, it spawns from February to September, but with a peak from April to June. The diameter of the eggs is from 6 to 8 mm (Mandić, 1984).

6.5.2 INPUT DATA

6.5.2.1 CATCH (LANDINGS AND DISCARDS)

The information available on the common cuttlefish in GSA 17-18 was very limited due to very low catches of this species along eastern coast of the Adriatic Sea. Also, fisheries from the eastern Adriatic coast of GSA 18 (i.e. non-EU countries Albania and Montenegro) is not included in DCF.

Data regarding the common cuttlefish, collected under framework of Data Collection Framework program, were assumed reliable, but stock related variables were not provided by Croatia at all, since exemption rules (due to low catches) were applied for this species. Data on size structure of common cuttlefish landings have been available only from Italy (i.e. western side of the Adriatic Sea) since 2006.

With aim of obtaining the longest reliable catch data series, beside DCF database, EWG 18-16 considered alternative catch data sources, such as economic transversal data, Istat, EUROSTAT and FAO FishStat databases, as well as outcomes of EU-RECFISH Project and data provided by DG-MARE. Data regarding this species from non-EU countries, Albania and Montenegro, are currently available from FAO FishStat database (up to 2016), but referring to different statistical division (i.e. Ionian Sea). Albanian data were also provided through DG-MARE.

Common cuttlefish usually occurs as a by-catch, caught together with other species by the same gear. Principal fishing gears catching common cuttlefish, together with other species (mixed catches) are bottom trawls (OTB), pots and traps (FPO) and "rapido" beam trawls (TBB). In addition, gillnets (GNS), and trammel nets (GTR), are also important fishing gears where common cuttlefish may occur as a part of the catches (Table 6.5.1.3). Furthermore, EWG 18-16 noticed difficulties in data interpretation of historical catch data, collected outside DCF, considering that this species was usually reported together with other species from families Sepiidae and Sepiolidae (e.g. S. elegans, S. orbignyana, Rossia macrosoma, etc.) or was not reported at all.

Data regarding the common cuttlefish, collected under framework of the Data Collection Framework program, were assumed quite reliable for the gears reported. Only few unreliable data occurred, such as catches of common cuttlefish reported by non-appropriate fishing gears (i.e. LLS). Taking in consideration that data by species collected through DCF are assumed reliable, the average ratio between catches of different Sepiidae, Sepiolidae species were calculated separately for each country based on available data. Then this information was used for estimating the historical catch data of common cuttlefish from fisheries statistic databases (EUROSTAT, FAO FishStat and historical national statistics).

Table 6.5.2.1.1 Common cuttlefish in GSA 17-18. Catch in the period 2006-2017 by fishing gears.

Gear	**tons**	**%**
OTB	25376.7	54.20%
FPO	9335.3	19.94%
TBB	6395.6	13.66%
GNS	3787.2	8.09%
GTR	1485.9	3.17%
FYK	428.5	0.92%
LLS	6.8	0.01%
-1	3.9	0.00%
All	**46821.0**	**100.00%**

However, when compared tables that were provided by different DCF datacalls, such as MED & BS datacall with transversal datasets (EAR datacall), it seems that not all gears, having common cuttlefish as a part of the catch, are reported in catch and landing data tables. Therefore, these tables of MED &BS data seem to be underestimating total catches of common cuttlefish in comparison with corresponding catch data from other sources.

Regarding the stock assessment of common cuttlefish in the Adriatic Sea (GSA 17-18), the major concern was the availability and reliability of historical catch data. In order to describe the historical catch of this species in the Adriatic, data from several available sources (such as: FAO FishStat, ISTAT, National statistics databases, DCF - Transversal data, DCF commercial data and data from EU-RECFISH project) were extracted and compared with each other.

The catch of the common cuttlefish by Italian fishery fleet in the Adriatic Sea for period from 1972 to 1999 were provided through activities of EU-RECFISH project (RECovery of FISheries Historical time series for the Mediterranean and Black Sea stock assessment- EASME/EMFF/2016/1.3.2.5/01/SI2.770039). The landings and discard data of common cuttlefish caught by Italian fishery fleet for period from 2008 to 2017 were available through DCF Commercial and Transversal datasets. The gap between 2000 to 2007 was the most concerning one considering that different databases (GFCM-FISHSTAT, ISTAT, EUROSTAT) contain different values for the same years. Although GFCM-FISHSTAT database contains the complete data from 1972 to the recent, the landings of *S. officinalis* were reported together with other similar species (Sepiidae, Sepiolidae etc). Additional difficulty was that landings from GSA 18 were reported as part of Ionian statistical division (GFCM 37.2.2). In order to reconstruct the missing data a linear regression of **y = 1.2292x - 1.5926 (based on estimating 2008 to 2016 DCF transversal data 'x' from** GFCM-FISHSTAT data 'y') was applied based on correlation between DCF transversal to give 2000 to 2007 catch of *S. officinalis* (Table 6.5.2.1.2).

The landings and discards of common cuttlefish of Slovenian, Croatian and Montenegrin fishery fleets were provided through GFCM-FISHSTAT and DCF transversal (SVN and HRV) datasets or national statistics bureau (HRV). For the period before 2008 in the landings of Croatian fishery fleet this species was reported together with similar species (Sepiidae, Sepiolidae etc). In order to reconstruct the historical dataset, the average ratio between the catches of common cuttlefish and other similar species was calculated based on available data from 2008-2016. The average share in catch of **0.078** of the other species were applied on historical data to calculate the Croatian landings of common cuttlefish.

The landings common cuttlefish of Albanian fishery fleet were provided by DG-MARE.

The combined data form all sources is shown in Table 6.5.2.1.2 to obtain the best input data for stock assessment. The total landings of common cuttlefish in the Adriatic Sea (GSA 17 and 18) from 1972 to 2017 ranged from 2,553 to 12,363 t with average value approx. 6,500 t (Figure 6.5.2.1.1). The largest amount of common cuttlefish in the Adriatic Sea has been landed by Italian fishing fleet.

Table 6.5.2.1.2 Common cuttlefish in GSA 17-18. History of commercial catches (t) by countries and GSAs (all fishing gears combined) as used in assessment.

Year	CROATIA GSA 17	SLOVENIA GSA 17	ITALY GSA 17	ITALY GSA 18	MONTENEGRO GSA 18	ALBANIA GSA 18	Ex Yugoslavia (SLO, HRV & MTN)	**Total catch (t)**
1972			6151	1109			174	**7433**
1973			5818	1086			160	**7063**
1974			5411	1063			192	**6666**
1975			6360	1432			218	**8010**
1976			4845	1357			244	**6446**
1977			5093	1273			194	**6560**
1978			3589	1163			170	**4922**
1979			4441	1148			140	**5729**
1980			9158	1289			199	**10646**
1981			6161	869			159	**7189**
1982			9203	1103			146	**10451**
1983			10379	1808			176	**12363**
1984			7244	1118			153	**8515**
1985			8955	1230			148	**10333**
1986			7987	3069			144	**11199**
1987			6336	1215			177	**7728**
1988			6534	1462			219	**8216**
1989			4724	1224			200	**6147**
1990			4902	835			276	**6013**
1991			6917	1854			158	**8929**
1992	154	12	4621	1442	2			**6231**
1993	187	21	4693	1322	6			**6229**
1994	109	4	10368	1185	5			**11671**
1995	109	10	6193	1620	9	39		**7979**
1996	94	6	4000	798	10	33		**4941**
1997	139	5	4563	755	9	33		**5504**
1998	198	18	3710	868	10	51		**4856**
1999	134	18	3431	593	10	51		**4237**
2000	127	11	2756	884	10	50		**3838**
2001	78	72	2707	1220	10	22		**4109**
2002	41	22	1447	981	10	52		**2553**
2003	65	25	2270	710	10	43		**3122**
2004	36	29	2005	597	10	70		**2747**
2005	74	33	4074	1630	8	75		**5893**
2006	65	24	5008	2040	15	86		**7239**
2007	84	41	8603	1207	18	47		**10000**
2008	73	15	6276	960	15	62		**7401**
2009	68	14	5683	1243	7	126		**7141**
2010	86	7	3375	1140	9	98		**4715**
2011	105	8	2324	866	11	90		**3403**
2012	169	10	2575	663	12	80		**3510**
2013	189	4	2956	1018	11	85		**4263**
2014	207	6	3195	811	13	75		**4306**
2015	192	4	3293	879	14	82		**4464**
2016	112	5	2975	970	14	83		**4160**
2017	106	3	1951	1617	14	83		**3774**

TABLE LEGEND:

- historical data for ex Yugoslavia (Source FAO FishStat)
- data source: FAO FishStat
- data from Albania (provided by DG MARE)
- DCF Italian data (Source: Transversal data)
- estimated historical Italian data (using regression parameters of transversal data vs fishstat data 2008-2
- historical Italian data (source: Project EU-RECFISH)
- Croatian national fishery statistics database
- DCF commercial data
- data missing; assumed to be equal as previous year

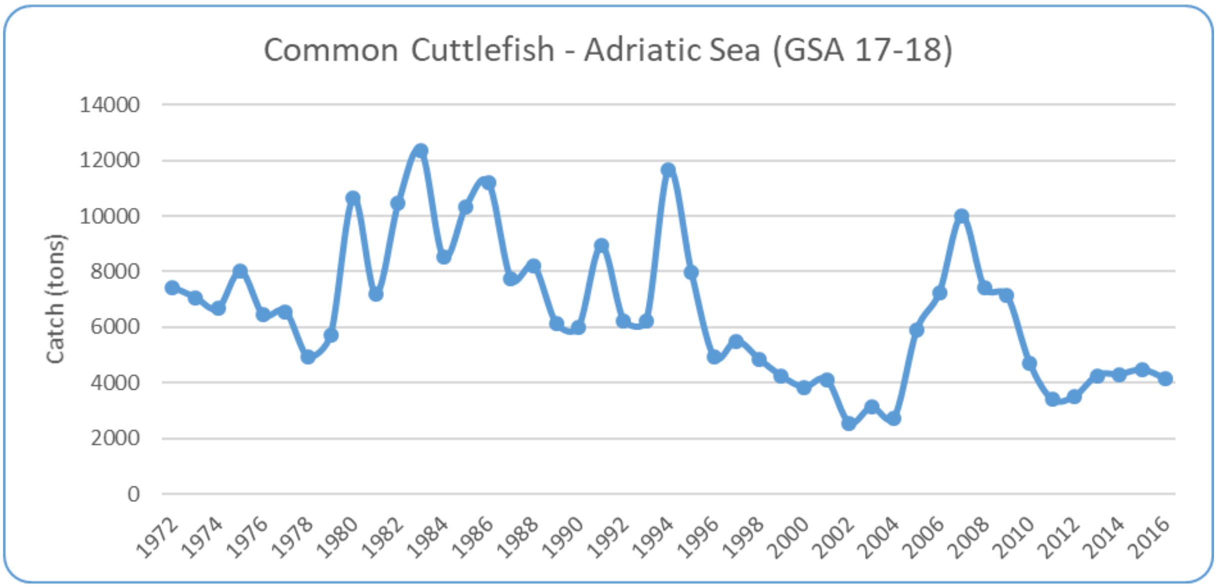


Figure 6.5.2.1.1 Common cuttlefish in GSA 17-18. Total catches.

Data on catch size structure were available only from Italian side of the Adriatic Sea by gears and by GSAs (GSA 17 and 18) in the period 2006-2017 as shown in Figures 6.5.2.1.2 and 6.5.2.1.3.

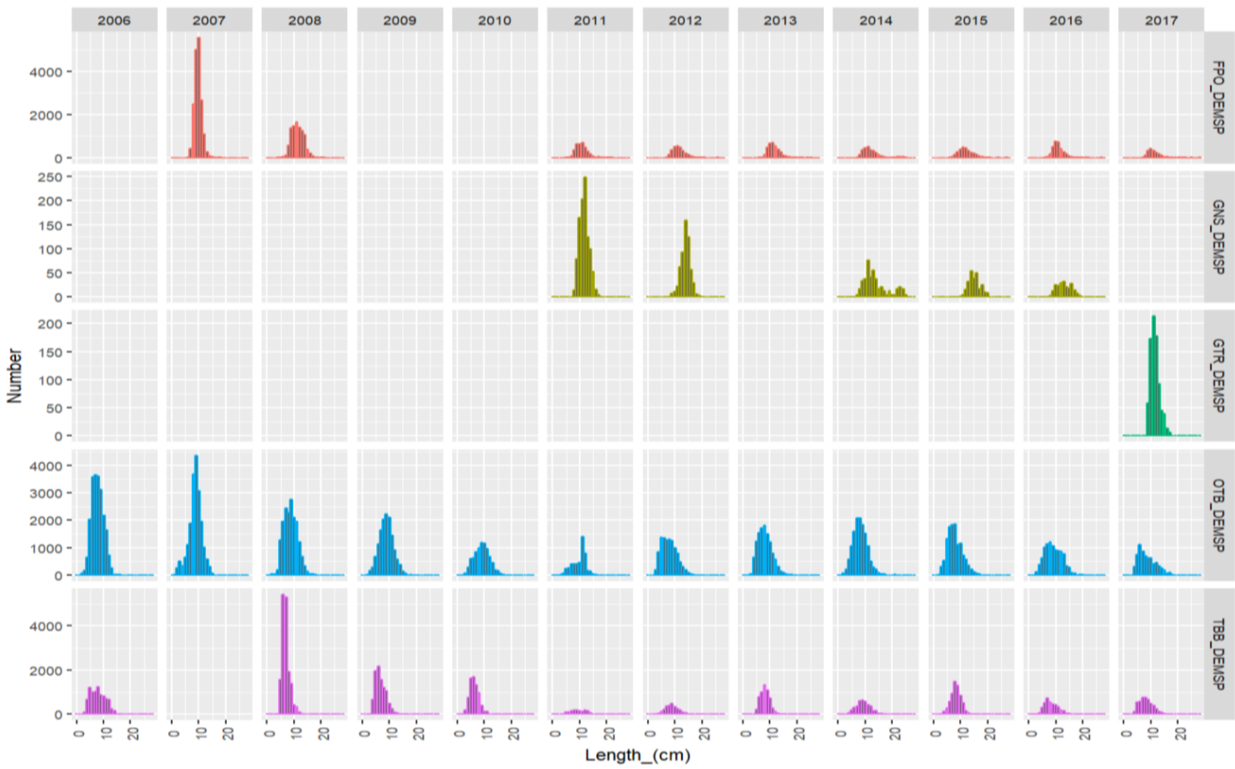


Figure 6.5.2.1.2 Common cuttlefish in GSA 17-18. Catch size distribution (mantle lengths in cm) in the western part of GSA 17 (ITA) by principal fishing gears.

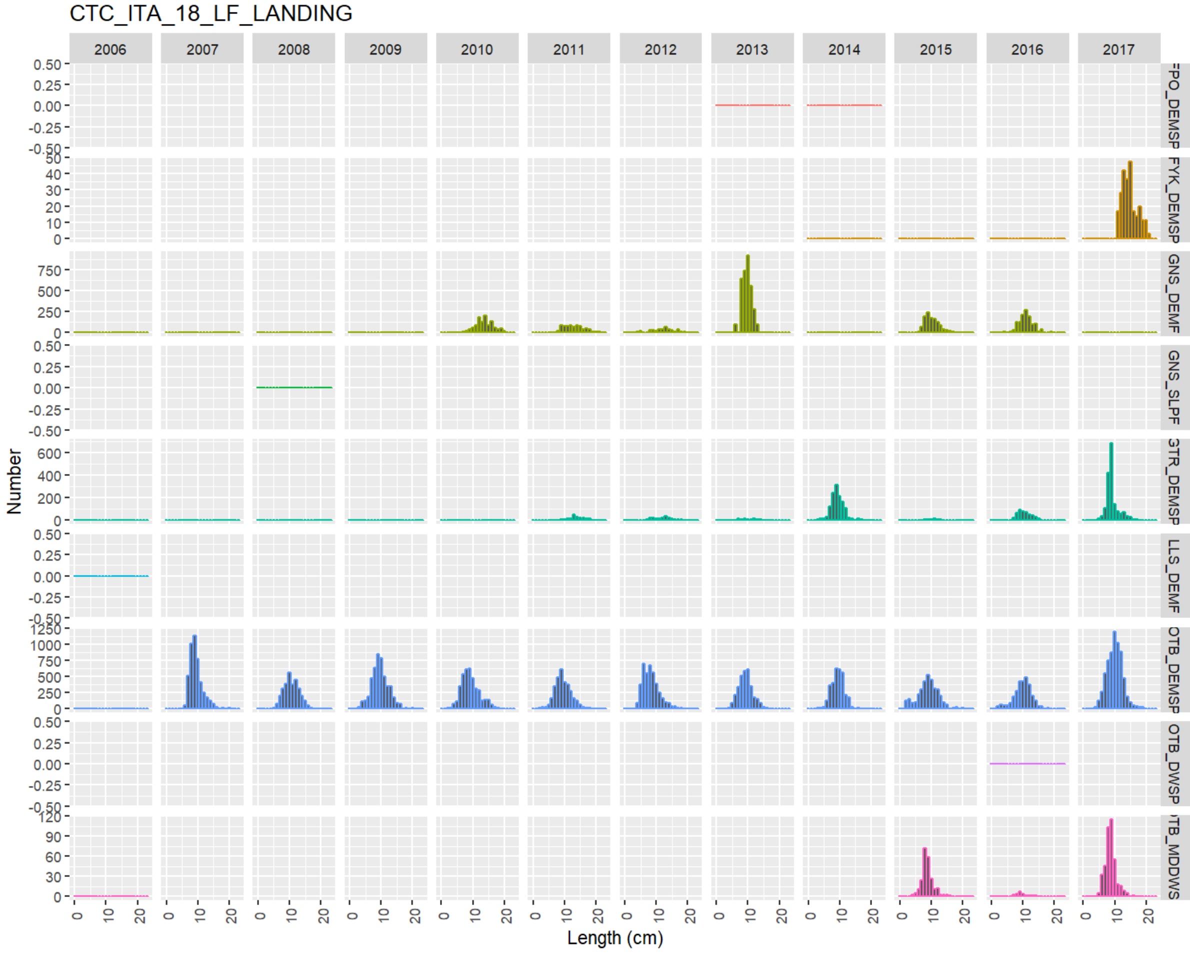


Figure 6.5.2.1.3 Common cuttlefish in GSA 17-18. Catch size distribution (mantle lengths in cm) in the western part of GSA 18 (ITA) by principal fishing gears.

Data on size distribution of common cuttlefish caught by Italian bottom trawlers in GSA 17 ranged from 1 to 27 cm (ML), while in GSA 18 the range was from 2 to 24 cm (Figure 6.5.2.1.2 and 6.5.2.1.3). Average mantle length of landed specimens in GSA 17 between 2006 and 2017 varied from 7.8 to 9.8 cm with overall average of 8.5 cm. In GSA 18 average length varied between 8.2 to 10.7 cm from 2007 to 2017 with overall average of 9.5 cm (Figure 6.5.2.1.4).

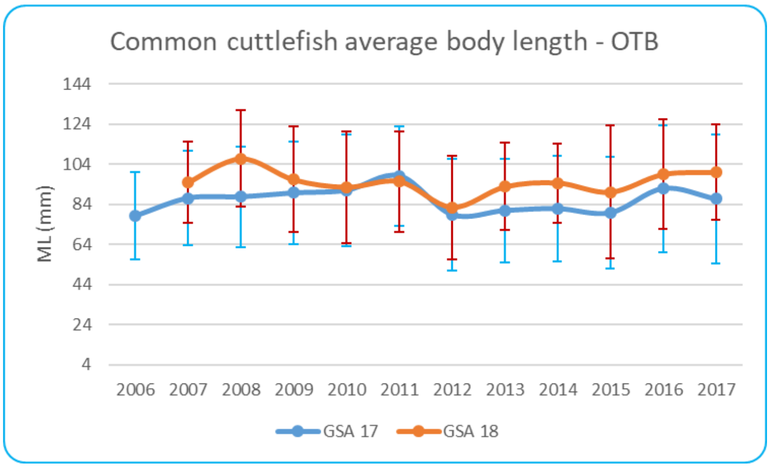


Figure 6.5.2.1.4 Common cuttlefish in GSA 17-18. Average mantle length of individuals landed by bottom trawl fisheries

Data on size distribution of common cuttlefish caught by Italian set net fisheries were scarce and available only for last several years. In GSA 17 it ranged from 7 to 25 cm (ML) (Figure 6.5.2.1.2), while in GSA 18 the range was from 3 to 23 cm (Figure 6.5.2.1.3). Average mantle length of landed specimens in GSA 17 between 2011 and 2017 varied from 11.6 to 15.2 cm with overall average of 12.7 cm. In GSA 18 average length varied between 9.3 to 13.7 cm from 2010 to 2017 with overall average of 10.6 cm (Figure 6.5.2.1.5).

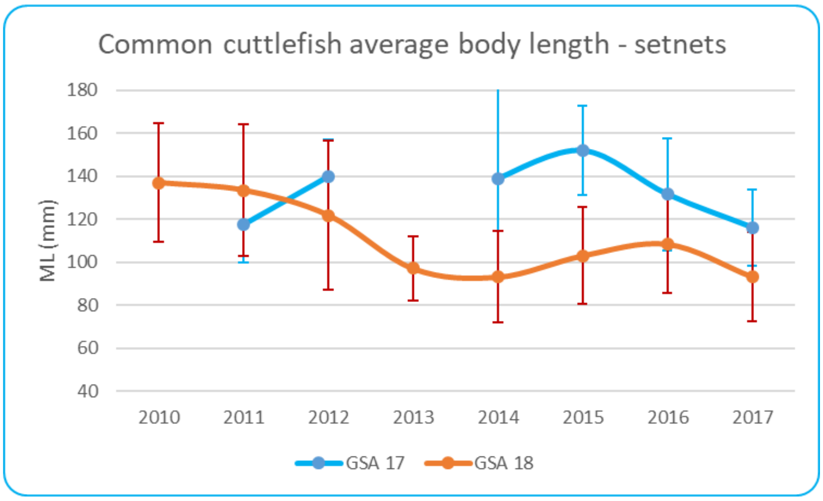


Figure 6.5.2.1.5 Common cuttlefish in GSAs 17 and 18. Average mantle length of common cuttlefish landed by Italian set net fisheries

Size distribution of common cuttlefish caught by Italian pot and traps (FPO) fisheries in GSA 17 ranged from 4 to 29 cm (ML), while in GSA 18 catches of common cuttlefish from this fishery are not reported in DCF tables. Average mantle length of landed specimens in GSA 17 between 2006 and 2017 varied from 9.7 to 12.1 cm with overall average of 10.8 cm. (Figure 6.5.2.1.6).

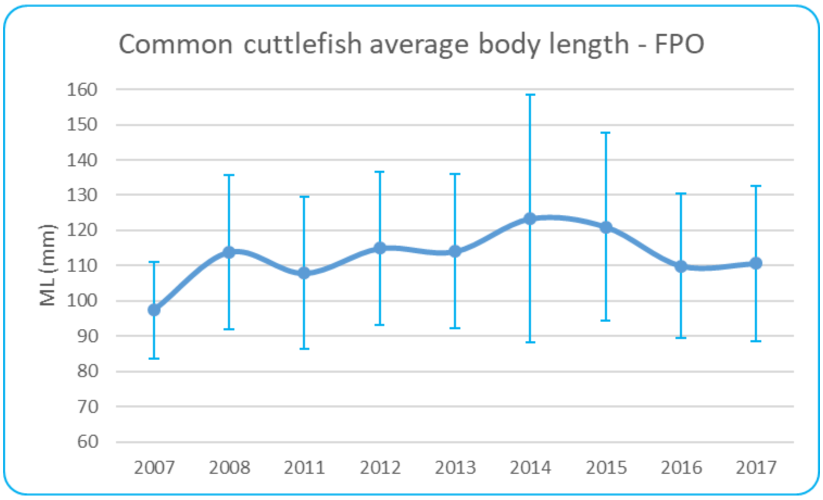


Figure 6.5.2.1.6 Common cuttlefish in GSAs 17-18. Average mantle length (right) of common cuttlefish landed by Italian FPO fishery in GSA 17.

Size distribution of common cuttlefish caught by Italian pot and traps (TBB) fisheries in GSA 17 ranged from 4 to 23 cm (ML), while in GSA 18 catches of common cuttlefish from this fishery are not reported in DCF tables. Average mantle length of landed specimens in GSA 17 between 2006 and 2017 varied from 6.3 to 9.8 cm with overall average of 7.7 cm. (Figure 6.5.2.1.7).

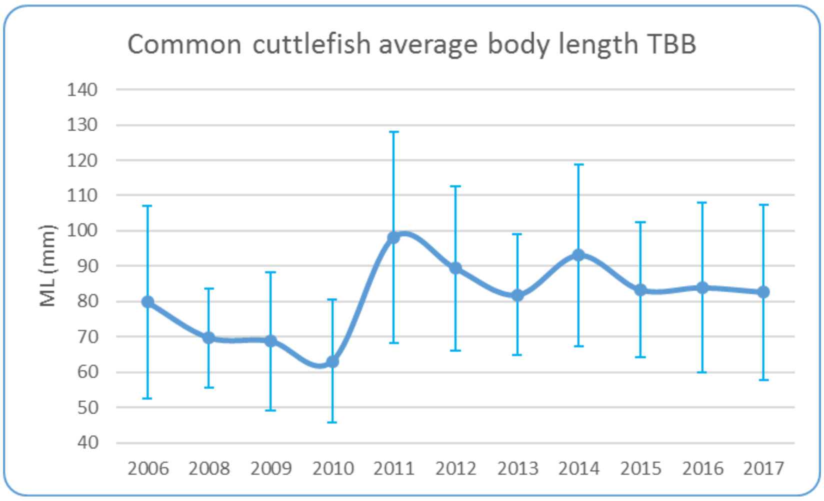


Figure 6.5.2.1.7 Common cuttlefish in GSAs 17-18. Average mantle length (right) of common cuttlefish landed by Italian TBB fishery in GSA 17.

Discards

Only the Slovenian fleet reported information on common cuttlefish discards for entire period covered by their DCF data, but without size structure. Italy reported data on discards are very scarce. Discard of common cuttlefish in Italy is reported in 2015 and 2017 for fishing gear TBB in GSA 17 only. No discards of common cuttlefish are reported by Croatia, and no discards are reported in GSA 18 also. In general, amount of discarded common cuttlefish catch is very low, practically negligible in comparison to the total landings of this species, and EWG 18-16 concluded that landing information can be considered as catch data of this species.

6.5.2.2 EFFORT

Common cuttlefish is caught by mixed fisheries, using several fishing gears (gillnets, trammel nets, trawls), by fishing boats of different sizes (different metiers, VL0006 - VL1824). In such situation, being common cuttlefish only one component of entire catches, fishing effort related to common cuttlefish only cannot be obtained.

Problems with fishing effort data (for fishing gears catching common cuttlefish) from Italy, describing days-at-sea and/or fishing days were noticed. Consequently, EWG 18-16 realized that all indices derived from days-at-sea (i.e. nominal effort and GT days-at-sea), are probably biased/non reliable (see Section 6.5.6). These issues prevented EWG 18-16 to use effort data provided and to perform all the analyses as requested in the ToR. It has been concluded that, as a first step, available DCF effort data accuracy/quality in JRC database need to be checked by member states (see section 7).

6.5.2.3 SURVEY DATA

Survey data comes from MEDITS surveys. In GSA 17 MEDITS data are available from 1996 to 2017. In GSA 18 Italian data were available from 1994, while in Albania first survey has been held in 1996, while in Montenegro MEDITS survey start from 2008.

The MEDITS surveys were carried out annually, usually during spring-summer period by all Adriatic countries. However, in some years MEDITS surveys, covering western part of the Adriatic Sea, were delayed and carried out in autumn, even in winter period (2007 in Slovenian waters) (Figure 6.5.2.3.1.). All available MEDITS data (survey indices) from Adriatic countries (GSAs 17 and GSA 18) were combined and data series from 1994 to 2017 is obtained.

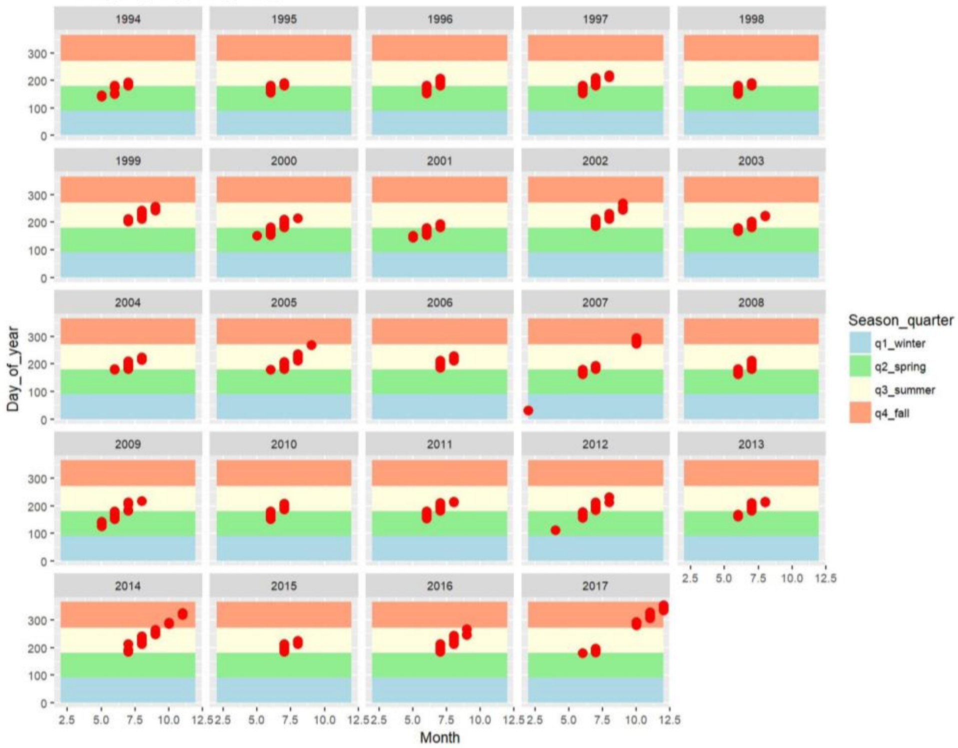


Figure 6.5.2.3.1 Common cuttlefish in GSA 17-18. MEDITS survey period in GSA 17 and 18 from 1994 to 2017

The common cuttlefish in GSA 17-18 shows oscillating trend in their mean standardized abundance/biomass indices during the time series analyzed, but in generally, negative trend is visible from 2002 to 2011. Starting from 2012, positive trend appears with significantly high values in 2014, 2016 and 2017 (Figure 6.5.2.3.2). However, these values should be taken with caution considering that in these years' surveys in the western part of the Adriatic Sea were performed in later period (late November in 2014, late September in 2016, and during December in 2017). The noted high values could be affected by behavioral characteristics of common cuttlefish like seasonal migration and grouping of individuals.

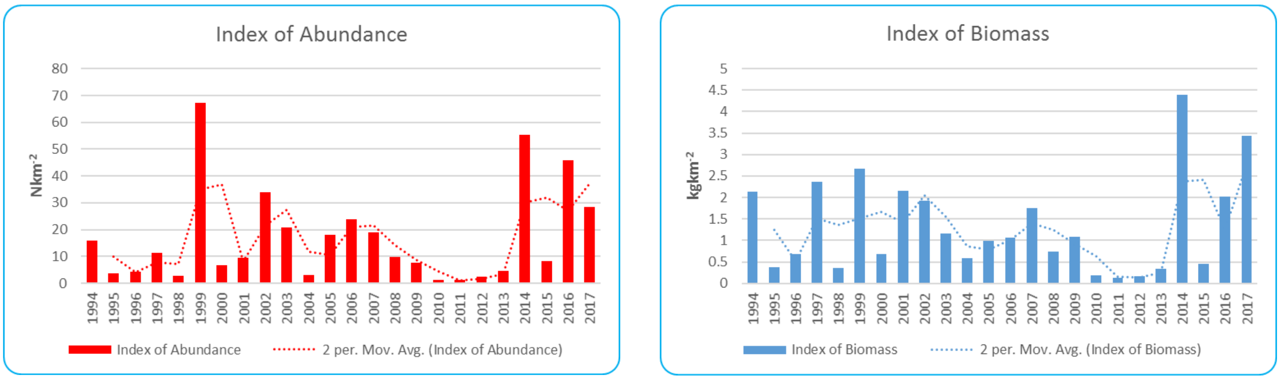


Figure 6.5.2.3.2 Common cuttlefish in GSAs 17 and 18. Index of abundance and biomass of common cuttlefish in GSA 17 and 18

Geomorphological characteristics in the Adriatic Sea (GSA 17 and GSA 18), like type of sediment and area of depth strata, have an influence on distribution of this species. In GSA 17 the shallower area covered with sandy sediments along Italian coast predominates in comparison to "rocky" Croatian coast and southern part of Adriatic (GSA 18). Southern part is characterized with narrow costal platform covered mostly by muddy sediments which limits distribution of common cuttlefish. Its occurrence fluctuates during the MEDITS surveys time series, but in generally is usually significantly higher in GSA 17 showing that *Sepia officinalis* is more abundant and widespread in GSA 17 than in GSA 18. (Figure 6.5.2.3.3 and 6.5.2.3.4).

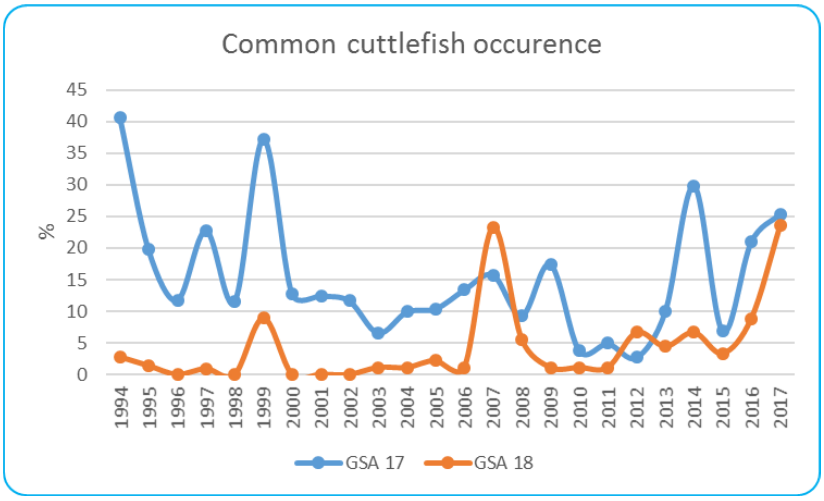


Figure 6.5.2.3.3 Common cuttlefish in GSA 17-18. Occurrence during the MEDITS surveys 1994-2017.

Abundance and biomass indices in GSA 17 ranged from 0.9 Nkm^{-2}/0.07 kgkm^{-2} (2012) to 70 Nkm^{-2}/5.6 kgkm^{-2} (2014) with overall average of 20.06 Nkm^{-2}/1.65 kgkm^{-2}. Higher values in some years should be taken with caution considering the period when survey has been conducted (in 2002 and 2016 in late September, while in 2014 it was late November and in December of 2017). Since occurrence of common cuttlefish in GSA 18 is sporadic, fluctuation of the indices are more pronounced. The overall average was 4.6 Nkm^{-2} and 0.29 kgkm^{-2} for GSA 18. The higher values noted in 2007 should be taken with caution due time of survey which has been in October. Trends of indices by GSA and countries are showed on Figure 6.5.2.3.5.

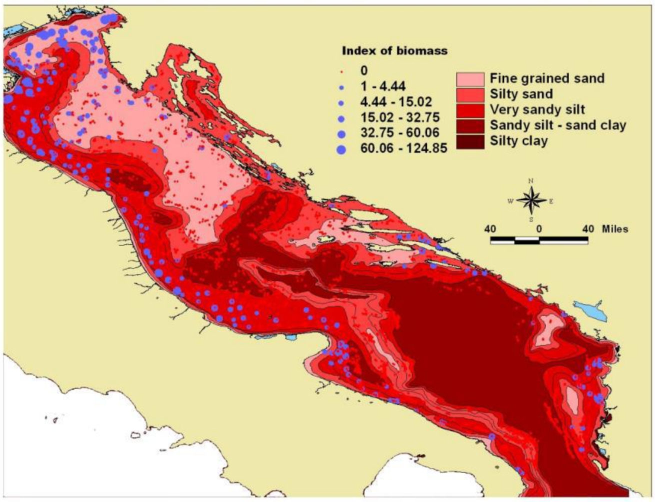
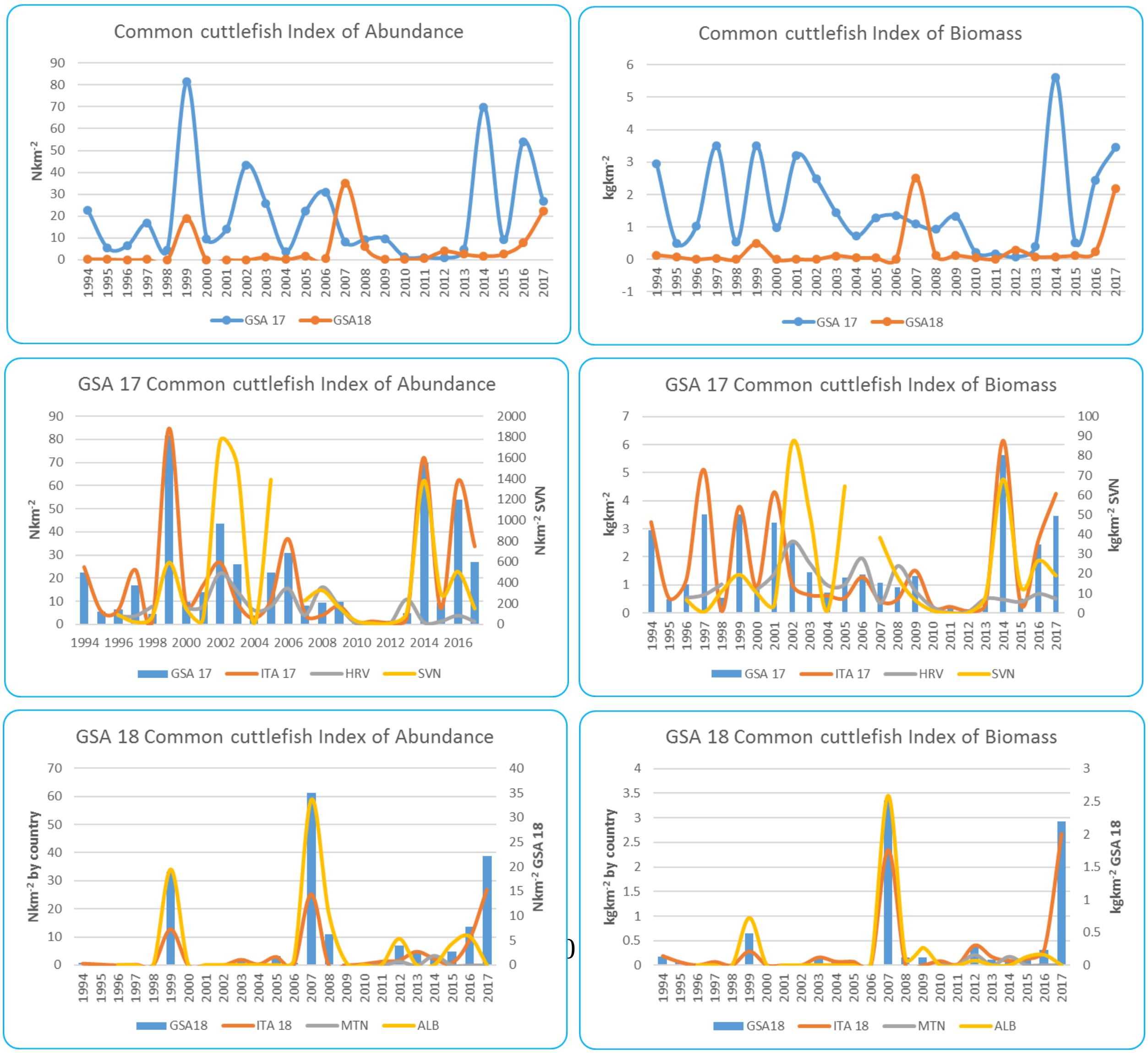


Figure 6.5.2.3.4 Common cuttlefish in GSAs 17 and 18. Distribution of common cuttlefish by depth and sediment type in the Adriatic Sea.

Figure 6.5.2.3.5 Common cuttlefish in GSAs 17 and 18. Trends of density indices in GSA 17 and 18 by countries during MEDITS surveys

Length distributions and size trends The overall size distribution of common cuttlefish in GSA 17 and 18 from the MEDITS surveys ranged from 1.5 to 21.5 cm of mantle length with average of 8.27 cm in GSA 17 and 8.37 cm in GSA 18 (Figure 6.5.2.3.6 and



6.5.2.3.7).

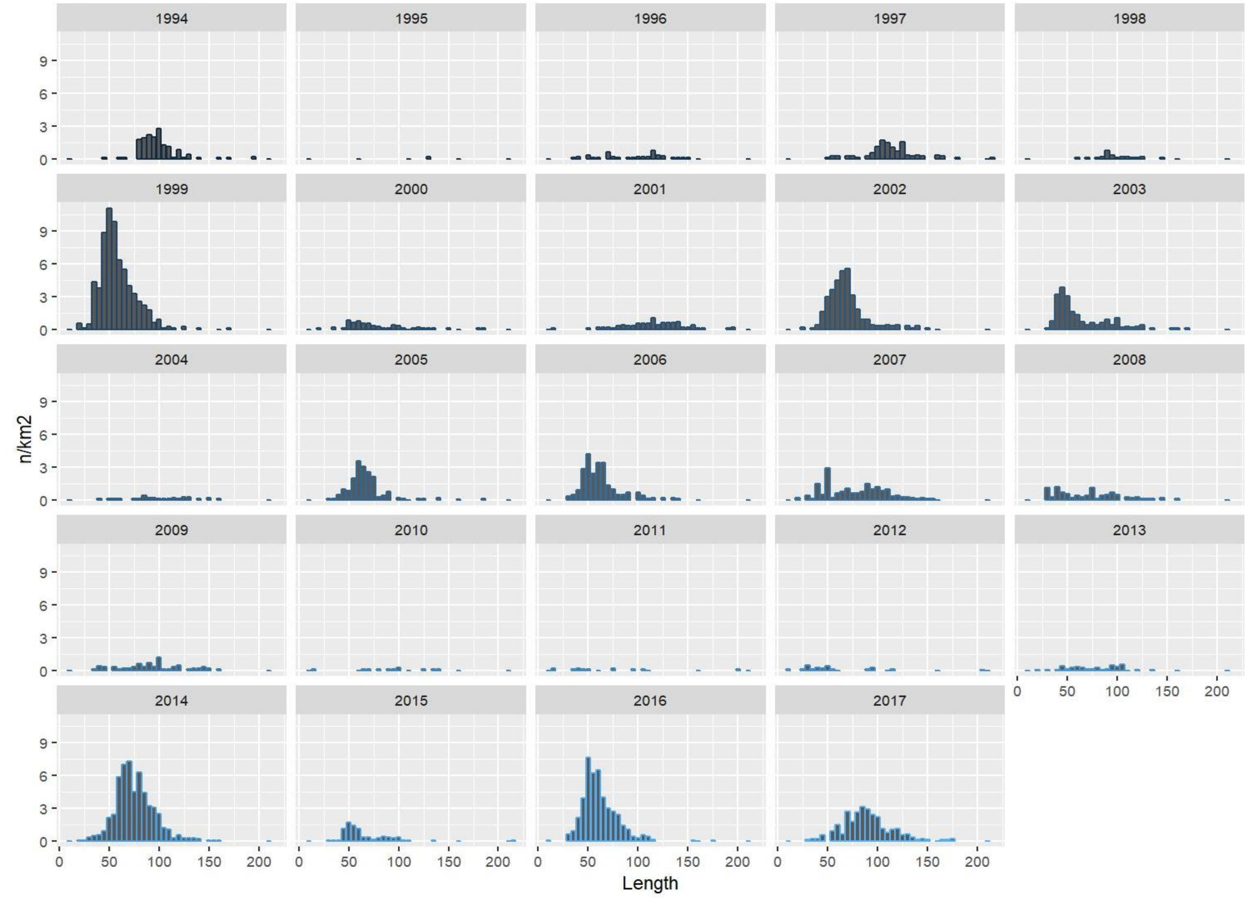


Figure 6.5.2.3.6 Common cuttlefish in GSA 17-18. Length structure (in mm) sampled during surveys in GSA 17 and 18 combined (MEDITS, 1994-2017).

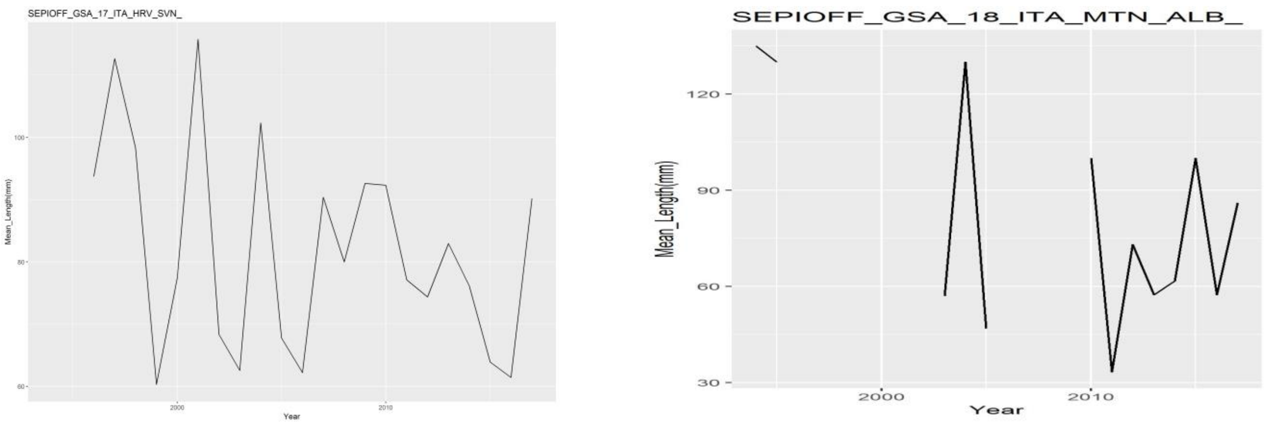


Figure 6.5.2.3.7 Common cuttlefish in GSAs 17 and 18. Trends of average mantle length of common cuttlefish in GSA 17 (a) and GSA 18 (b) during the MEDITS surveys

6.5.3 STOCK ASSESSMENT

After comprehensive analysis of the data provided throughout the DCF data call and fisheries statistical databases for this area EWG 18-16 noticed some shortages of information. The main issues were partial availability of size data from commercial fisheries and insufficiency of growth parameters for this species. This data limited situation prevents possibility to use age/size based assessment models. Therefore, taking in consideration shortage of biological data and the biological cycles of common cuttlefish which is short lived species (lifespan is around1 to 2 years maximum), surplus models were used in order to conduct stock assessment of common cuttlefish in GSA 17 and 18 combined.

6.5.3.1 METHOD 1: CMSY

CMSY is a Monte-Carlo method that estimates fisheries reference points (MSY, Fmsy, Bmsy) as well as relative stock size (B/Bmsy) and exploitation (F/Fmsy) from catch data and broad priors for resilience or productivity (r) and for stock status (B/k) at the beginning and the end of the time series. Part of the CMSY package is an advanced Bayesian state-space implementation of the Schaefer surplus production model (BSM). The main advantage of BSM compared to other implementations of surplus production models is the focus on informative priors and the acceptance of short and incomplete (= fragmented) abundance data. The required R-code (CMSY_O_7p.R) and some example input files (O_Stocks_Catch_14_Med.csv and O_Stocks_ID_17_Med.csv) can be downloaded from https://github.com/SISTA16/cmsy

Input data

Data as presented in Table 6.5.2.1.2.

Biomass

The biomass from MEDITS surveys in GSA 17 and 18 was used as tuning index. Survey data for complete area were available from 1996 onwards. Considering the extreme values of biomass index in 2014, which is most likely consequence of conducting the survey in late summer (autumn) period, data were extrapolated as mean value between previous and next survey. For the same reason the final survey (2017) were not used as tuning index.

Settings

Considering biology of this species that is described as fast growing, short living species with higher reproductivity potential (Relini et al., 1999; Vrgoč et al. 2004), resilience or productivity (r) prior was set at medium level. The selected r - value is in accordance with methodology used by the authors of model stated in Froese et al. 2016. The other priors have been set as medium depletion (0.2 - 0.6) at the begin of the series taking into account the high value of catches observed in the seventies and eighties in the central and northern Adriatic. Considering the strong positive trends in the index of biomass and occurrence of common cuttlefish during the last MEDITS surveys and slight positive trends in the catches of commercial fisheries, the final prior of relative biomass was set as low depletion.

Results of CMSY model

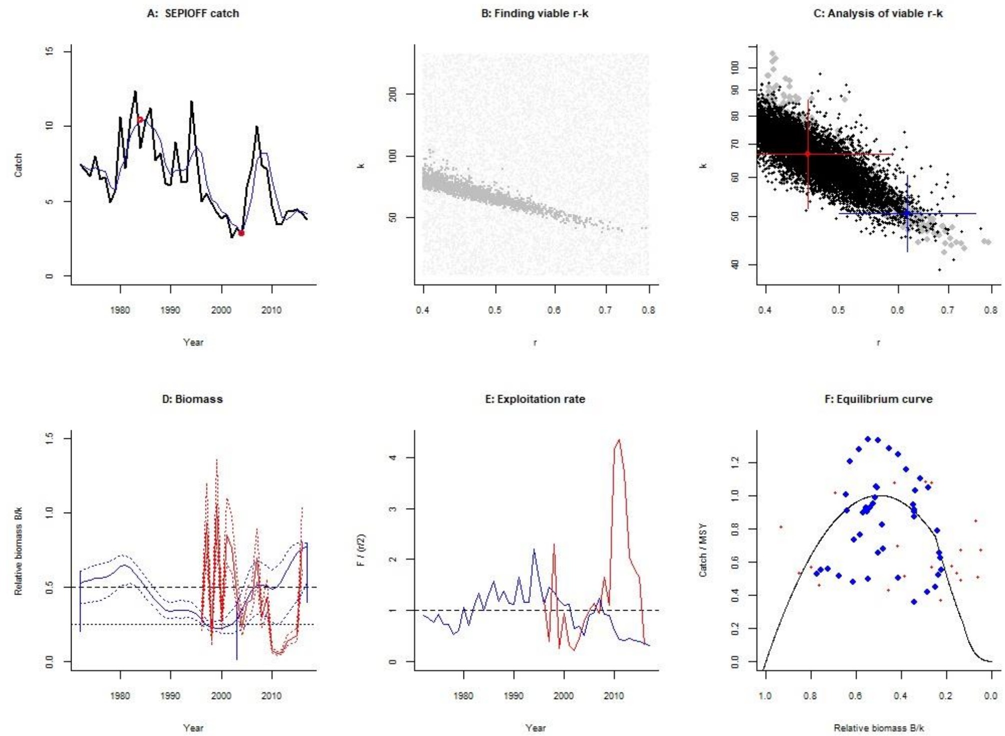


Figure 6.5.3.1 Common cuttlefish in GSAs 17 and 18. Summary of the final CMSY model fit and output. Catch curve, viable r-K paris and their analysis, relative biomass and fishing mortality, production curve of common cuttlefish.

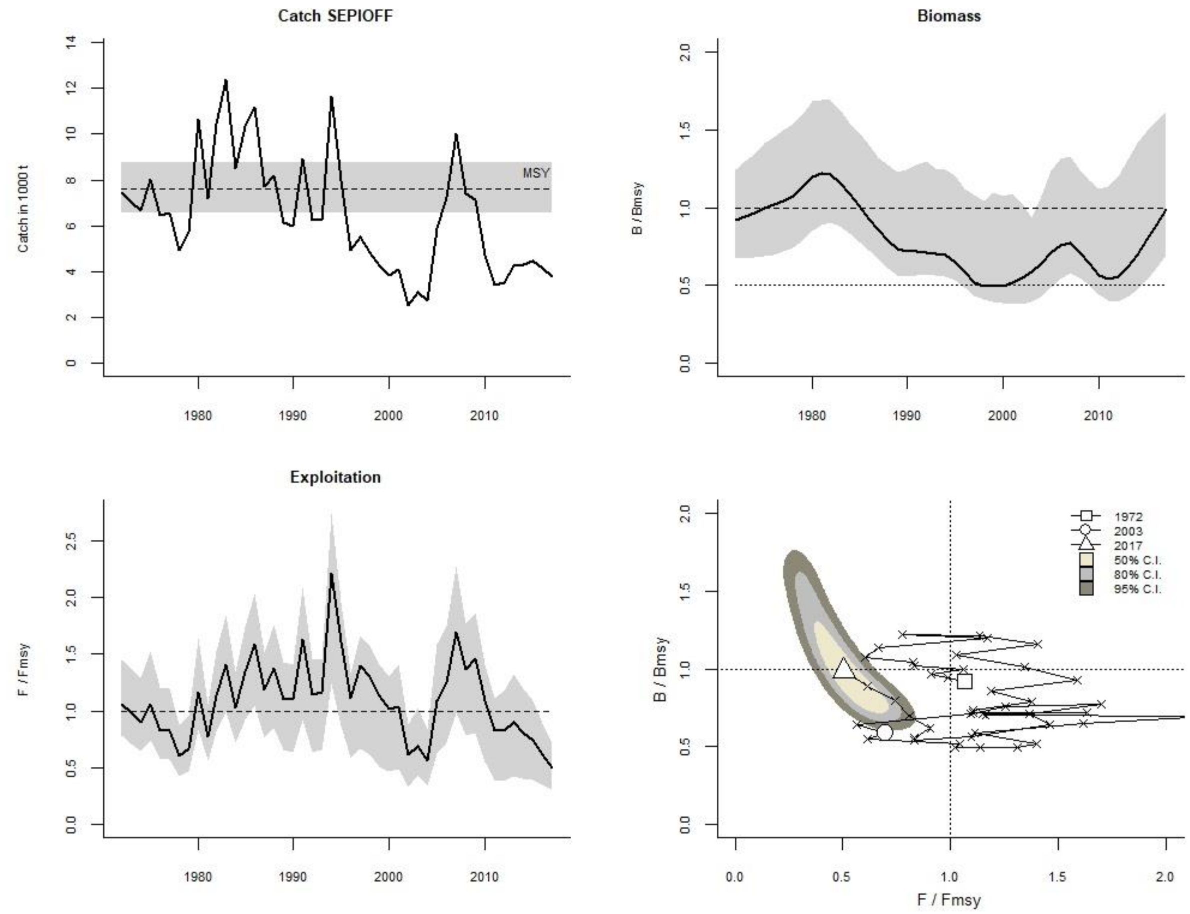


Figure 6.5.3.2 Common cuttlefish in GSAs 17 and 18. Relative biomass and fishing mortality, F/B plot and catch curve as given by the CMSY model for common cuttlefish.

The output of the model (Model estimates, reference points and summaries) are reported below.

Species: ***Sepia officinalis*** , stock: SEPIOFF

Cuttlefish in the Adriatic Sea

Source: NA

Region: Mediterranean, Adriatic Sea

Catch data used from years 1972 - 2017, abundance = CPUE

Prior initial relative biomass = 0.2 - 0.6 expert

Prior intermediate rel. biomass= 0.01 - 0.4 in year 2003 default

Prior final relative biomass = 0.4 - 0.8 expert

Prior range for r = 0.4 - 0.8 expert, , prior range for k = 26.1 - 313

Prior range of q = 2.35e-05 - 6.64e-05

Results of CMSY analysis with altogether 2308 viable trajectories for 1871 r-k pairs

r = 0.617 , 95% CL = 0.5 - 0.762 , k = 50.7 , 95% CL = 42.4 - 60.5

MSY = 7.82 , 95% CL = 7.24 - 8.46

Relative biomass last year = 0.775 k, 2.5th = 0.534 , 97.5th = 0.799

Exploitation F/(r/2) in last year = 0.311

Results from Bayesian Schaefer model using catch & CPUE

r = 0.455 , 95% CL = 0.352 - 0.589 , k = 66.8 , 95% CL = 52 - 86

MSY = 7.6 , 95% CL = 6.59 - 8.77

Relative biomass in last year = 0.493 k, 2.5th perc = 0.348 , 97.5th perc = 0.809

Exploitation F/(r/2) in last year = 0.503

q = 3.79e-05 , lcl = 2.98e-05 , ucl = 4.81e-05

Results for Management (based on BSM analysis)

Fmsy = 0.228 , 95% CL = 0.176 - 0.294 (if B > 1/2 Bmsy then Fmsy = 0.5 r)

Fmsy = 0.228 , 95% CL = 0.176 - 0.294 (r and Fmsy are linearly reduced if B < 1/2 Bmsy)

MSY = 7.6 , 95% CL = 6.59 - 8.77

Bmsy = 33.4 , 95% CL = 26 - 43

Biomass in last year = 32.9 , 2.5th perc = 23.2 , 97.5 perc = 54.1

B/Bmsy in last year = 0.986 , 2.5th perc = 0.696 , 97.5 perc = 1.62

Fishing mortality in last year = 0.115 , 2.5th perc = 0.0698 , 97.5 perc = 0.162

F/Fmsy = 0.503 , 2.5th perc = 0.307 , 97.5 perc = 0.714

Comment: NA

Conclusions to CMSY model

The CMSY model indicating the recent recovery of common cuttlefish stock with negative trends in exploitation rate and fisheries mortality and with biomass at the level of BMSY. However, the estimated confidence intervals were significant concerning both the estimates of exploitation rate and relative biomass. Considering these results and short lifecycles that is highly dependent on environmental factors , EWG recommends the precautionary approach.

6.5.3.2 METHOD 2: SPICT

The stochastic surplus production model in continuous-time (SPiCT) incorporates dynamics in both biomass and fisheries and observation error of both catches and biomass indices. The model has a general state-space form that as special cases contain process and observation-error models as well as state-space models that assume errorfree catches. More information on the SPiCT assessment method is described in Pedersen and Berg (2016).

Input data

Data as presented in Table 6.5.2.1.2.

Biomass

The biomass from MEDITS surveys in GSA 17 and 18 was used as tuning index. Survey data for complete area were available by from 1996 onwards. Considering the extreme values of biomass index in 2014, which is most likely consequence of conducting the survey in late summer (autumn) period, data were extrapolated as mean value between previous and next survey. For the same reason the final survey (2017) were not used as tuning index.

Settings

The setup of the model parameters and variables on relative biomass, relative fishing mortality and K for the start years were required for the model to converge. The priors were setup in takin in consideration of the biology of this species that is described as fast growing, short living species with higher reproductivity potential, and the assumption on status of the stock at the beginning of catch time series. The Schaefer production model was selected.

Results

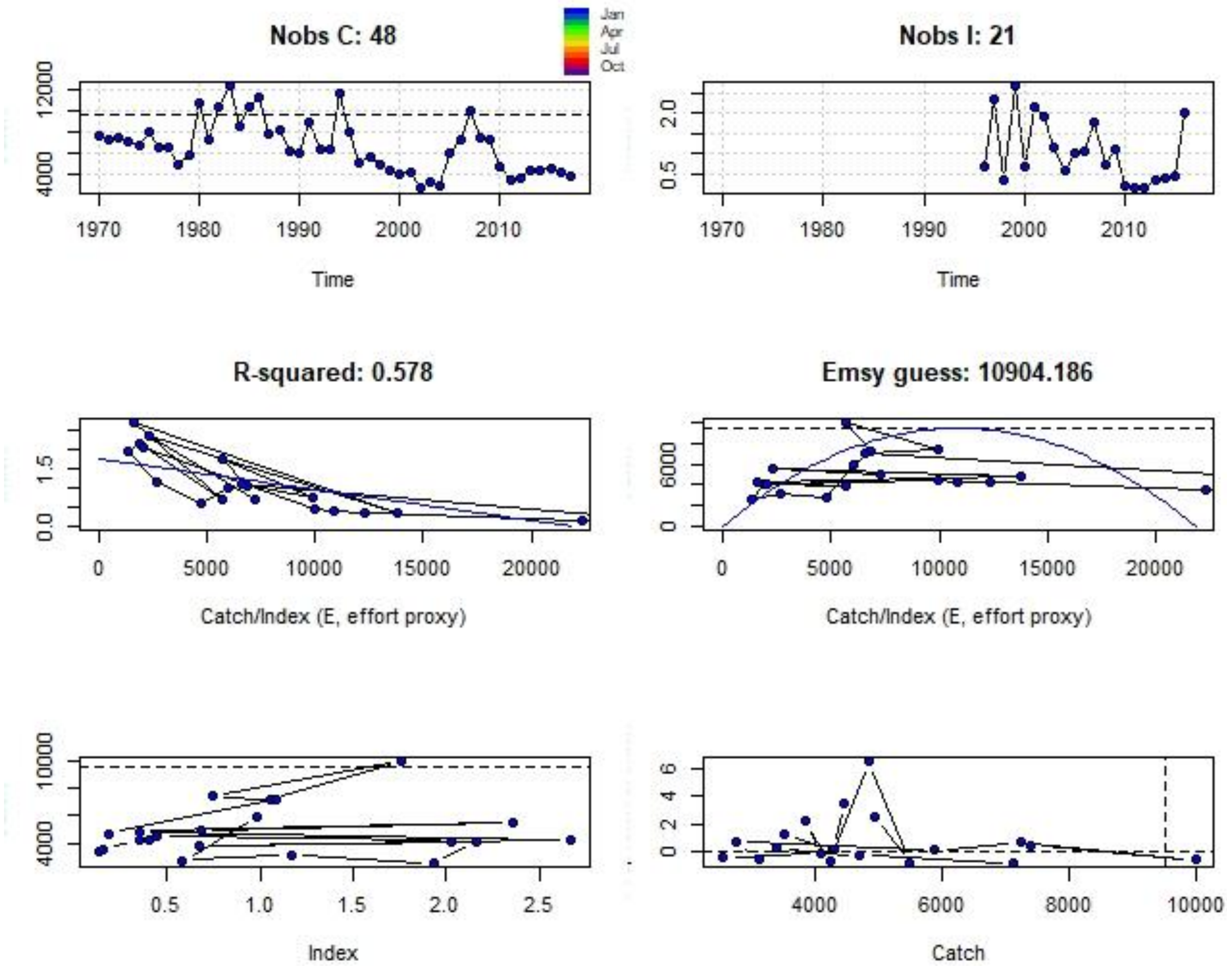


Figure 6.5.3.3 Common cuttlefish in GSAs 17 and 18. Input data and explorative analysis for stock assessment of common cuttlefish in GSA 17-18

The assessment results show that for the period 2010-2015, the common cuttlefish stock was not fished in a sustainable manner. The current biomass and fishing mortality are above Bmsy and below Fmsy estimates, but the uncertainty around those estimates is high. (Figure 6.5.3.4)

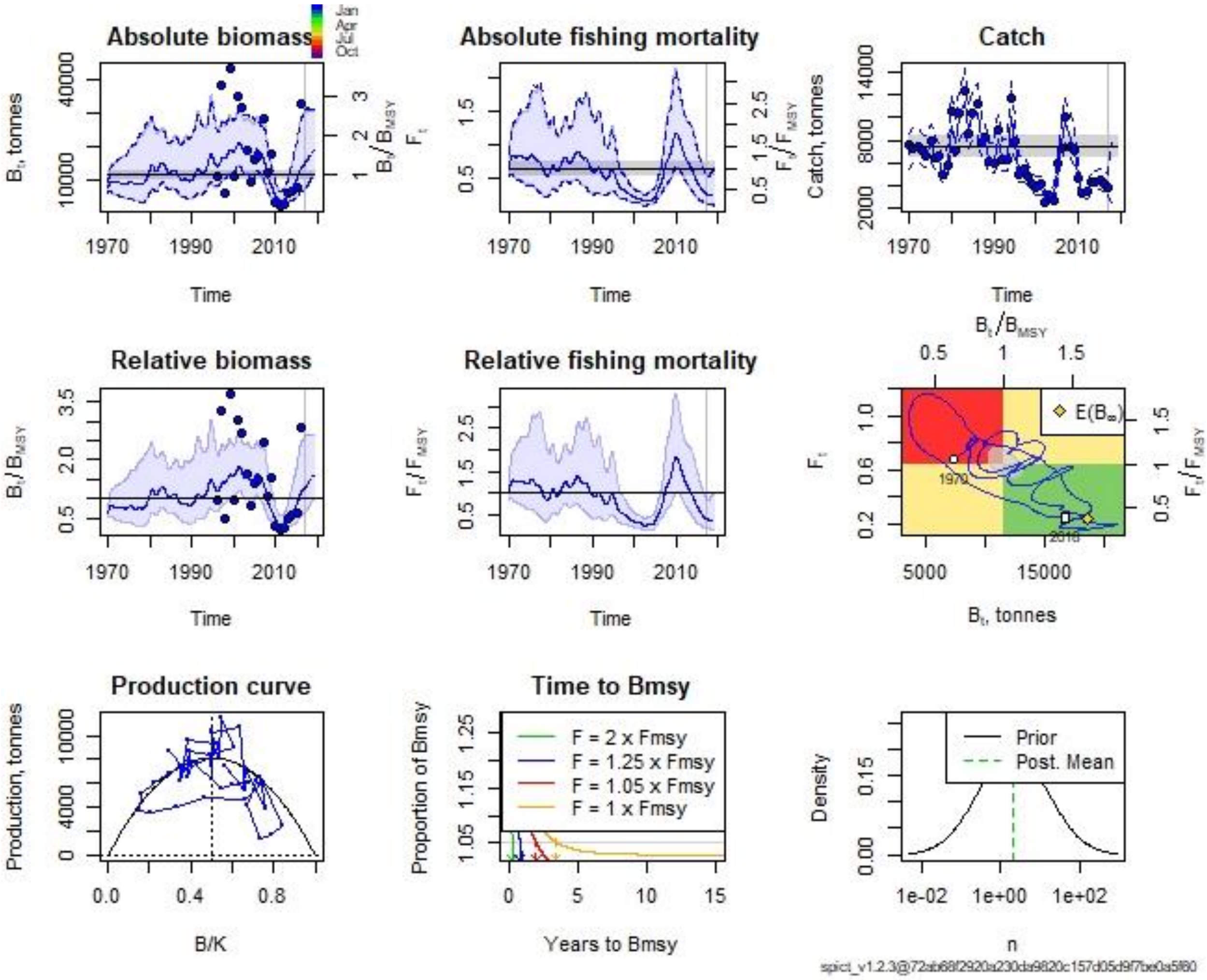


Figure 6.5.3.4 Common cuttlefish in GSAs 17 and 18. Summary of the final SPiCT model fit and output. Absolute and relative Biomass and Fishing mortality, state of the stock in F/B space and relative to estimated production.

The output of the model (Model estimates, reference points and summaries) are reported below.

[1] "Convergence: 0 MSG: both X-convergence and relative convergence (5)"

[2] "Objective function at optimum: 47.9218297"

[3] "Euler time step (years): 1/16 or 0.0625"

[4] "Nobs C: 48, Nobs I1: 21"

[5] "Catch/biomass unit: tonnes "

[6] ""

[7] "Priors"

[8] "   logn ~ dnorm[log(2), 2^2]"

[9] "   logalpha ~ dnorm[log(1), 2^2]"

[10] "   logbeta ~ dnorm[log(1), 2^2]"

[11] " logBBmsy1970.00 ~ dnorm[log(0.6), 0.1^2]"

[12] " logFFmsy1970.00 ~ dnorm[log(1), 0.1^2]"

[13] ""

```
[14] "Fixed parameters"
[15] "   fixed.value  "
[16] " K    24726.47  "
[17] " n        2.00  "
[18] ""
[19] "Model parameter estimates w 95% CI "
[20] "           estimate        cilow        ciupp    log.est  "
[21] " alpha     2.2003142    0.9796519    4.9419418  0.7886002  "
[22] " beta      0.4168038    0.1698796    1.0226385 -0.8751397  "
[23] " r         1.3152319    1.1333685    1.5262777  0.2740130  "
[24] " rc        1.3152319    1.1333685    1.5262777  0.2740130  "
[25] " rold      1.3152319    1.1333685    1.5262777  0.2740130  "
[26] " m      8130.2610569 7006.0507512 9434.8652616  9.0033483  "
[27] " q         0.0000618    0.0000419    0.0000912 -9.6918301  "
[28] " sdb       0.2717407    0.1301999    0.5671508 -1.3029071  "
[29] " sdf       0.2890871    0.1825669    0.4577575 -1.2410271  "
[30] " sdi       0.5979148    0.4221942    0.8467718 -0.5143069  "
[31] " sdc       0.1204926    0.0575599    0.2522325 -2.1161668  "
[32] " "
[33] "Deterministic reference points (Drp)"
[34] "           estimate        cilow        ciupp    log.est  "
[35] " Bmsyd 12363.235600 1.236324e+04 1.236324e+04  9.4224825  "
[36] " Fmsyd     0.657616 5.666842e-01 7.631388e-01 -0.4191342  "
[37] " MSYd   8130.261057 7.006051e+03 9.434865e+03  9.0033483  "
[38] "Stochastic reference points (Srp)"
[39] "           estimate        cilow        ciupp    log.est rel.diff.Drp  "
[40] " Bmsys 1.159284e+04 1.051413e+04 1.278221e+04  9.3581427  -0.06645471  "
[41] " Fmsys 6.435856e-01 5.609647e-01 7.383751e-01 -0.4407003  -0.02180030  "
[42] " MSYs  7.450174e+03 6.560198e+03 8.460886e+03  8.9159926  -0.09128475  "
[43] ""
[44] "States w 95% CI (inp$msytype: s)"
[45] "                   estimate        cilow        ciupp    log.est  "
[46] " B_2017.00      1.478647e+04 7098.6946020 3.080000e+04  9.6014681  "
[47] " F_2017.00      2.678522e-01    0.1271732 5.641504e-01 -1.3173199  "
[48] " B_2017.00/Bmsy 1.275484e+00    0.6222142 2.614628e+00  0.2433254  "
[49] " F_2017.00/Fmsy 4.161874e-01    0.1917446 9.033470e-01 -0.8766196  "
[50] ""
[51] "Predictions w 95% CI (inp$msytype: s)"
[52] "                 prediction        cilow        ciupp    log.est  "
```

[53] " B_2018.00 1.673389e+04 8963.8468695 3.123915e+04 9.7251911 "
[54] " F_2018.00 2.428791e-01 0.1095599 5.384292e-01 -1.4151915 "
[55] " B_2018.00/Bmsy 1.443468e+00 0.7883480 2.642994e+00 0.3670484 "
[56] " F_2018.00/Fmsy 3.773843e-01 0.1661286 8.572812e-01 -0.9744912 "
[57] " Catch_2018.00 4.286860e+03 2347.2583819 7.829206e+03 8.3633098 "
[58] " E(B_inf) 1.864226e+04 NA NA 9.8331862 "

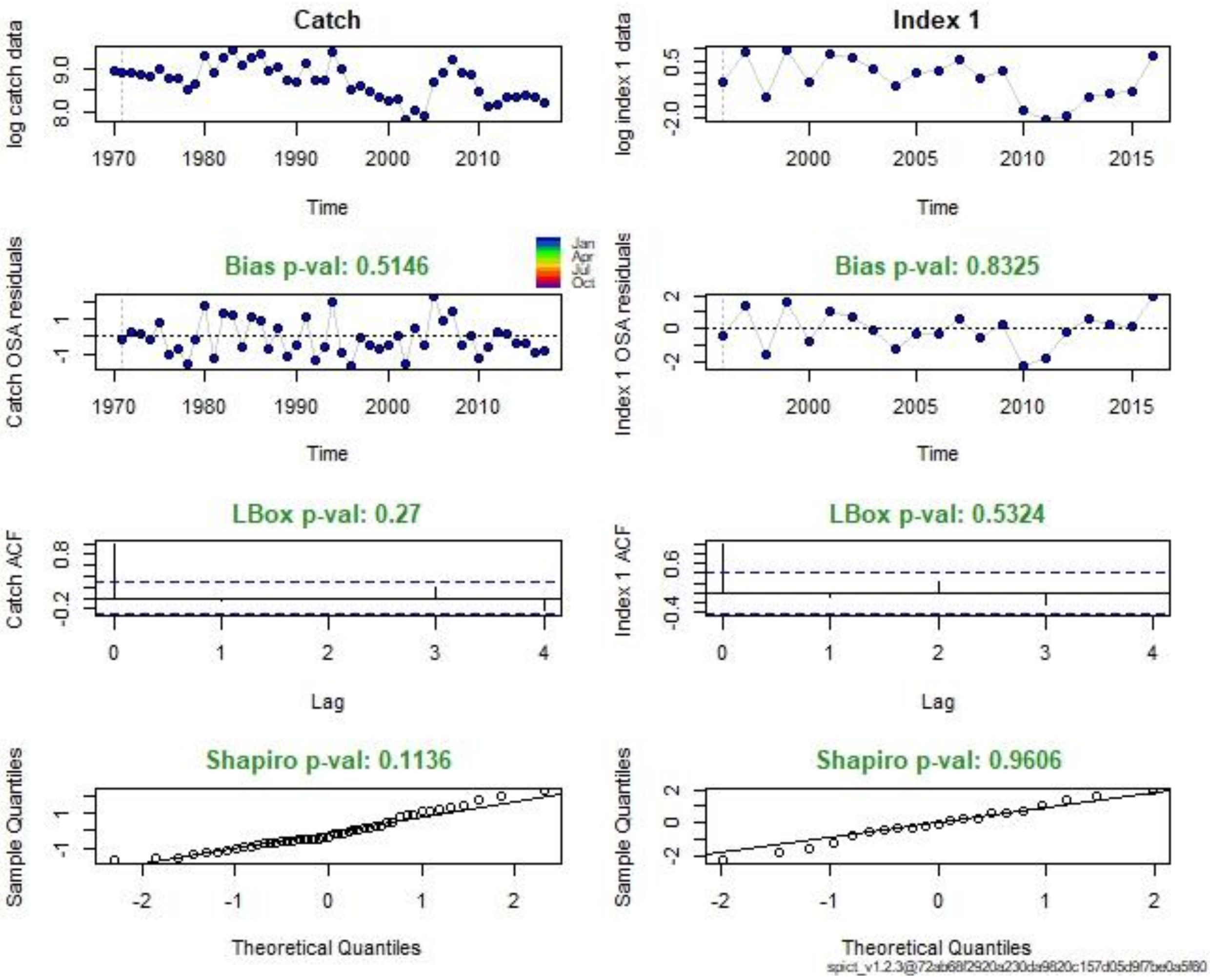


Figure 6.5.3.5 Common cuttlefish in GSAs 17 and 18. Diagnostics from SPiCT model for common cuttlefish in GSA 17-18.

Retrospective analysis

A retrospective analysis was run with 5 retro years, but the retrospective patterns showed instability in final years, sensitivity to the final data points. Patterns were more consistent across years in terms of B/Bmsy but not so in terms of F/Fmsy. This could imply that the current state of the stock is uncertain.

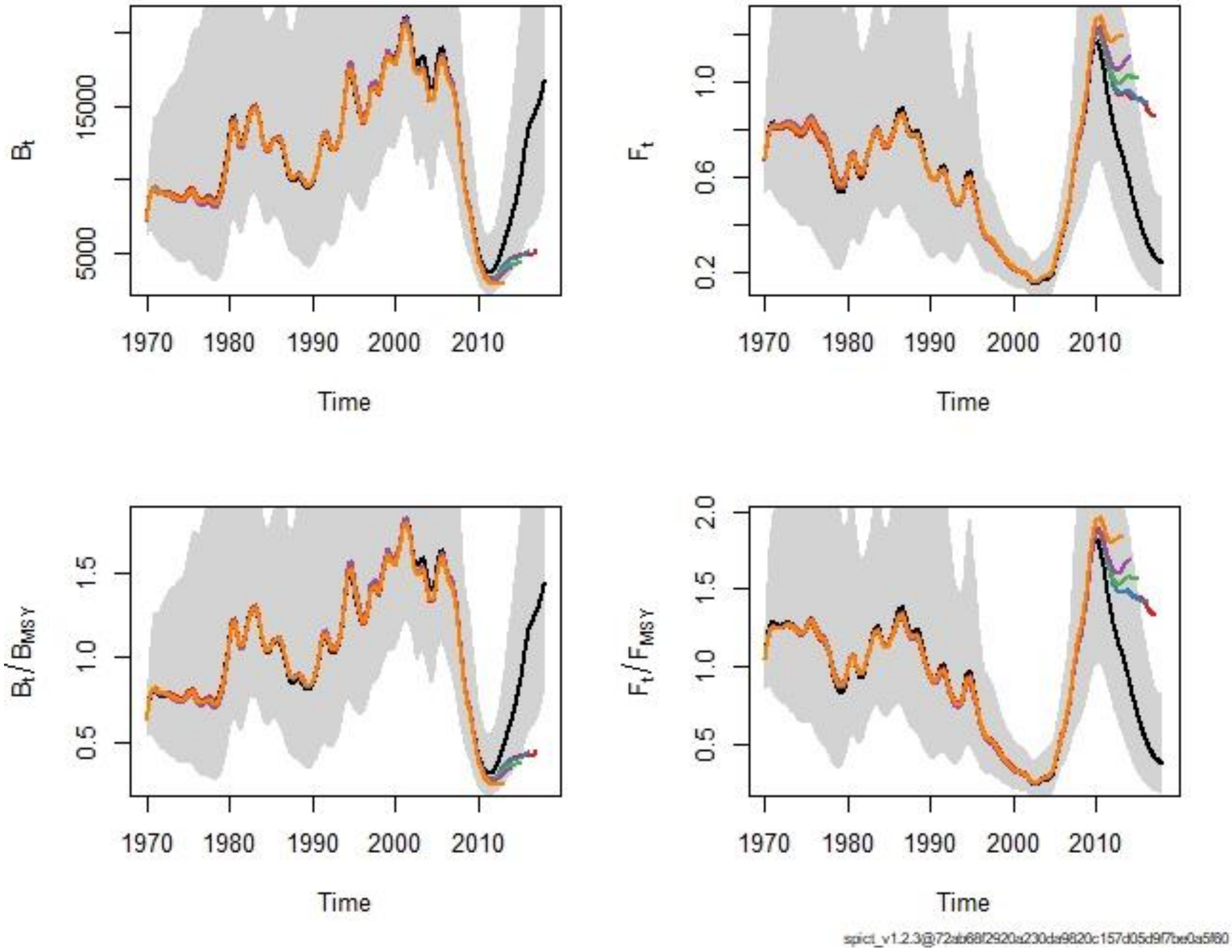


Figure 6.5.3.6 Common cuttlefish in GSAs 17 and 18. Retrospective analysis for the SPiCT model for common cuttlefish in GSA 17-18

Conclusions to SPiCT model

EWG concluded that results of this model were biased by setting the priors on model parameters and variables. Furthermore, due to high uncertainties of estimated parameters and instabilities in retrospective analysis, EWG was not able to determine current stock status or biomass based on results of this model. Thus, this assessment will not be used for specific advice.

6.5.4 REFERENCE POINTS

Area	Species	Method/ basis	F 2017	F 2019	Change in F	Catch 2017	Catch 2019	Change in catch	Biomass (status)
GSA 17-18	Common cuttlefish	CMSY	0.5 F MSY	F=F MSY	101%	3774	7600	101%	At Bmsy

6.5.5 SHORT TERM FORECAST AND CATCH OPTIONS

Although both used models showed recovery of the common cuttlefish stock in the Adriatic Sea (GSA 17 and 18) with reference points approaching or close to safe limits, precautionary approach was recommended for a management of this species.

The major factor that can affect the recovery is complex population dynamics which highly depend on environmental factors. It is usual that individuals which belong to same population of common cuttlefish have different growth parameters, one with shorter and another with longer life cycles. Duration of life cycles most likely depend on season of hatchery which is in other hand influenced by duration and intensity of day light, temperature and other abiotic factors (Richard, 1971; Boletzky, 1983; Le Goff and Daguzan, 1991). Furthermore, all the cuttlefish appear to die immediately after breeding leaving significantly reduced spawning stock. Due to that, instability of environmental factors can rapidly affect the status of the stock regarding the management measures conducted by authorities.

6.6 Sole in GSA 17

6.6.1 Stock Identity and Biology

The assessment on common sole carried out during the STECF EWG 18-16 considered the stock confined within the boundaries of GSA 17 (Fig. 6.6.1).

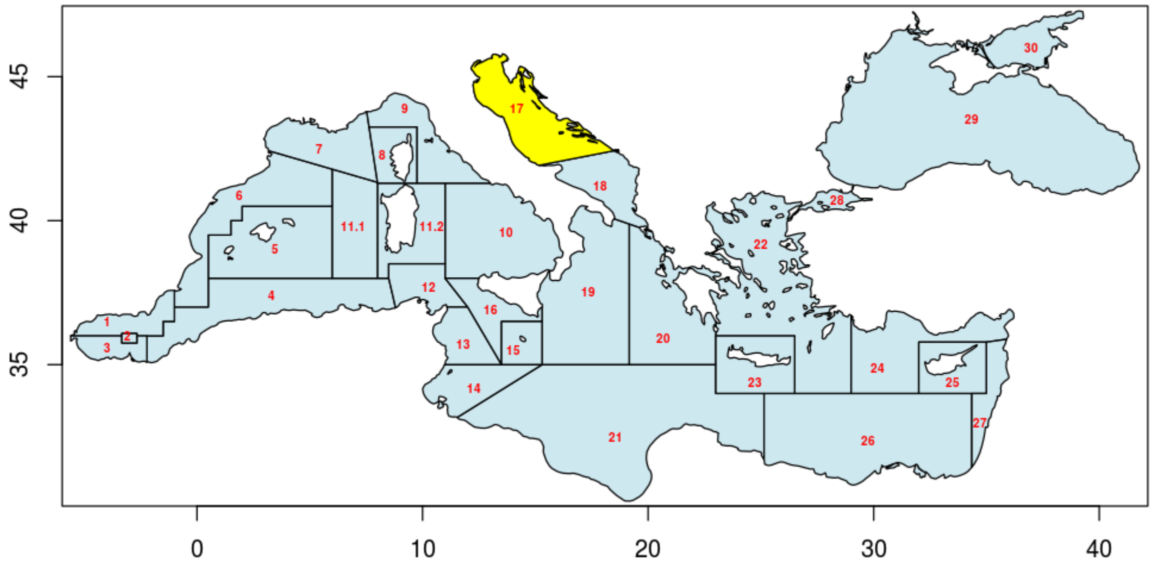


Figure 6.6.1 Geographical location of GSA 17.

Solea solea is a demersal and sedentary species, living on sandy and muddy bottoms (Tortonese, 1975, Fisher et al., 1987, Jardas, 1996). In the central and northern Adriatic Sea the reproduction takes place from November to March. Data on the spatial distribution of spawners provided by the SoleMon project show a higher concentration of reproducers outside the western coast of Istria (Fabi et al., 2009).

In the Adriatic sea, growth analyses on this species have been made using otoliths, scales and tagging experiments. A great variability in the growth rate was noted: some specimens had grown 2 cm in one month, while others, of the same age group, needed a whole year (Piccinetti and Giovanardi, 1984). Von Bertalanffy growth equation parameters have been calculated using various methods. Within the framework of SoleMon project, growth parameters of sole were estimated through the length-frequency distributions obtained from surveys. Considering age estimation obtained until now from otolith readings has been suggested by Italian and Croatian experts to be unreliable, as some inconsistencies in the procedures have been found, and considering age matrices data were judged by the EWG 18-16 not reliable due to internal inconsistencies, new age matrices were produced during the working group in order to explore the effects of this change on the assessment.

Within the EWG 18-16 the growth parameters from Fabi et al. (2009) (Table 6.6.1.1) were used as reference when refitting the growth curves to LFDs (Figure 6.6.1.1) from Solemon survey by adapting t_0 to define new growth curves (Table

6.6.1.1). These parameters were then used in the routine L2a to slice the LFDs data for survey and catch and obtain new age matrices that were used in the a4a assessment.

Table 6.6.1.1. Sole in GSA 17. Growth parameters used by EWG 18-16

Author	Linf	k	t0	Sex
Fabi et al. (2009)	39.6	0.44	-0.46	M+F
EWG 18-16	39.6	0.44	0.58	M+F

Age matrices available from the official DCF data call were used in the SS3 assessment while new age matrices obtained from the slicing procedures were used for the a4a assessment.
Length at first maturity used for the SS3 assessment is 25 cm (Fisher et al., 1987; Jardas, 1996; Vallisneri et al., 2000); The proportion of mature by age estimated by SoleMon data is presented in Table 6.6.1.2, together with the natural mortality vector estimated using the PRODBIOM spreadsheet (Abella et al., 1997). For the a4a assessment length at full maturity was obtained from official DCF data and it was 22 cm; proportions of mature per age class (Table 6.6.1.3) was obtained from SoleMon lenght frequencies distributions. Natural mortality at age was calculated using the PRODBIOM spreadsheet as well, but with the new set of growth parameters (Table 6.6.1.1).

Table 6.6.1.2. Sole in GSA 17. Maturity and mortality at age vectors used in the SS3 assessment.

	0	1	2	3	4	5+
Maturity	0	0.16	0.76	0.96	0.99	1
M	0.7	0.35	0.28	0.25	0.23	0.22

Table 6.6.1.3 Sole in GSA 17. Maturity and mortality at age vectors used in the a4a assessment.

	1	2	3	4	5+
Maturity	0	0.47	1	1	1
M	0.84	0.37	0.29	0.25	0.23

Median values of length-weight relationship parameters a (0.00735) and b (3.0585) to define the mean weight at age matrix were obtained from the DCF 2018 (Table 6.6.1.4).

Table 6.6.1.4. Sole in GSA 17. Length-weight relationship parameters

Year	a	b
2006	0.023	2.708
2007	0.023	2.708
2008	0.011	2.916
2009	0.0041	3.233
2010	0.009	2.996
2011	0.0028	3.364
2012	0.0084	3.01
2013	0.0063	3.107
2014	0.0052	3.159
2015	0.0102	2.957
2016	0.0021	3.443

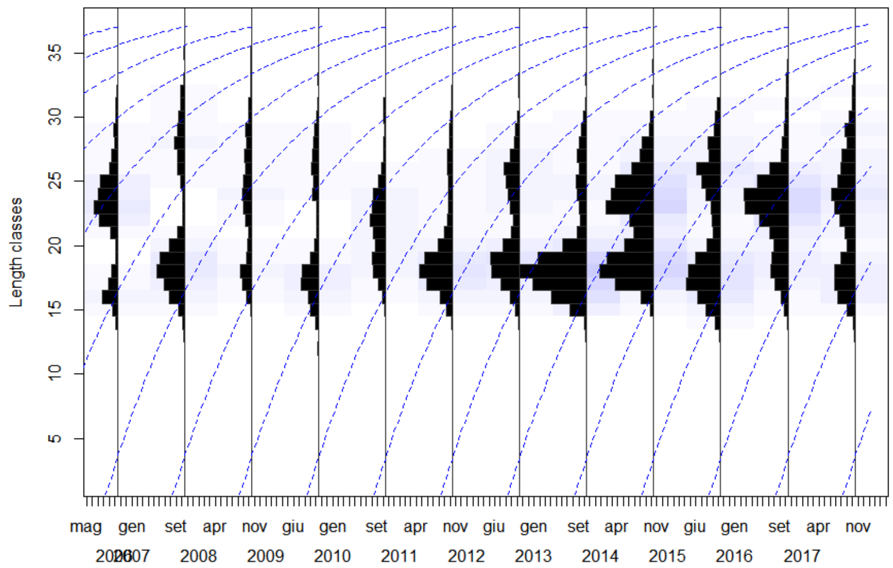


Fig. 6.6.1.2 Sole in GSA 17. Growth curve refitted to LFDs.

6.6.2 Data

6.6.2.1 Catch (landings and discards)

As discards for this species are negligible, assessment section landings values will be referring to catch values.

The common sole is a very important commercial species in the central and northern Adriatic Sea (Ghirardelli, 1959; Piccinetti, 1967; Jardas, 1996; Vallisneri et al., 2000; Fabi et al., 2009). Italian rapido trawlers exploit this resource, usually providing about 50% of the landings. Sole is also a target species of the Italian and Croatian set netters, and it represents an accessory species for otter trawlers.

The Italian fleet provides the bulk of the landings, while the eastern part of the basin contributes for about the 10% of the total landings, with on average 10 tons from Slovenia and 200 tons from Croatia (Fig. 6.6.2.1.1).

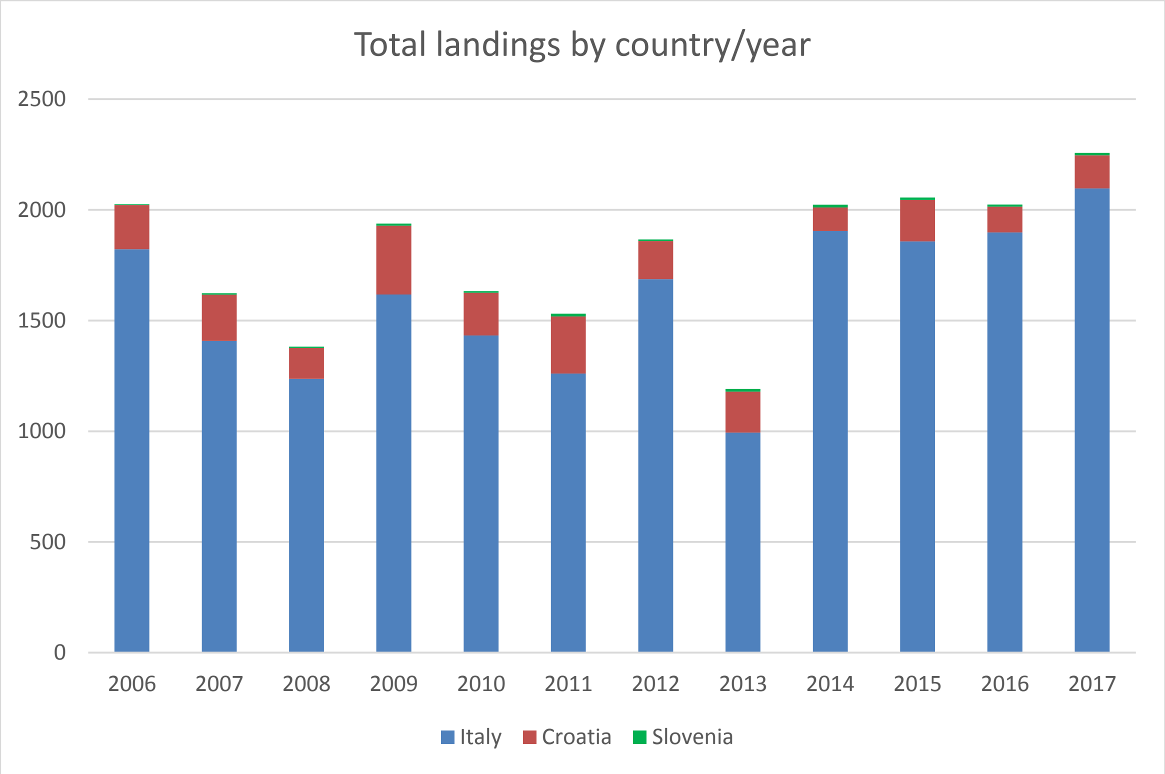


Figure 6.6.2.1.1. Sole in GSA 17. Total landings by country from 2006 to 2016.

Regarding the Italian fleet, the rapido trawl, providing about the 50% of the total landings, gives the highest proportion (Fig. 6.6.2.1.2).

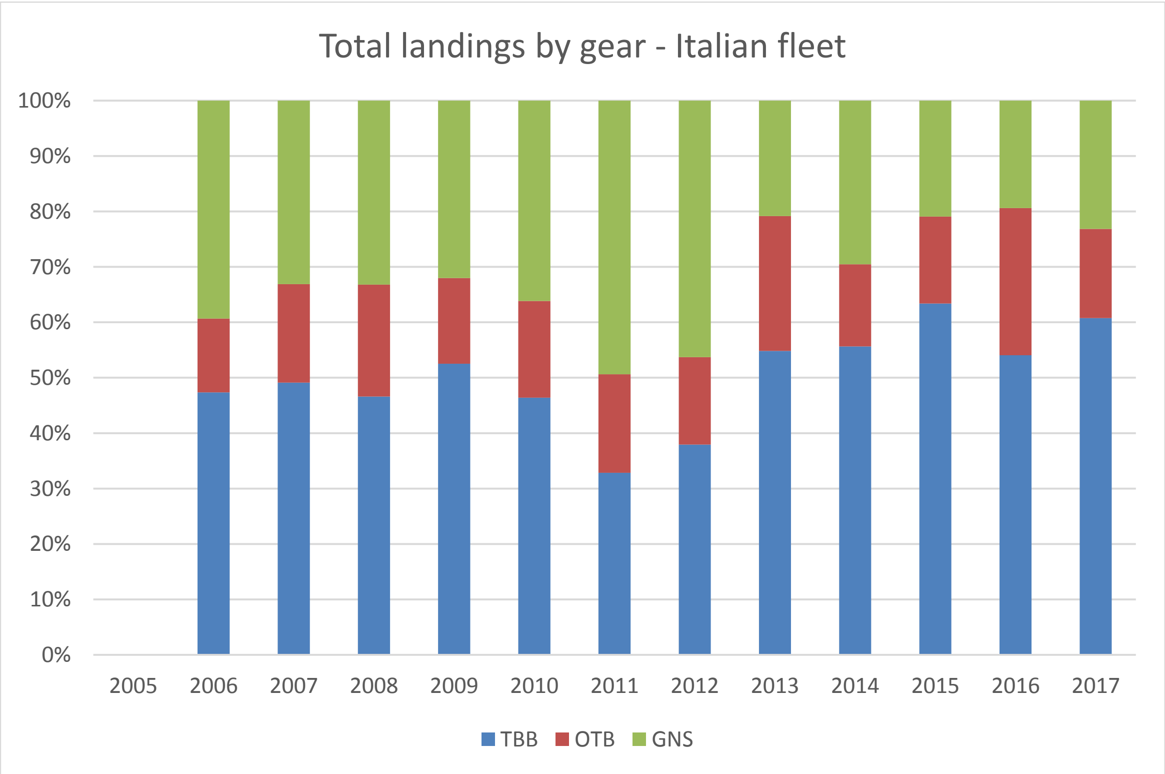


Figure 6.6.2.1.2. Sole in GSA 17. Percentage of Italian landings (by gears) in the GSA 17, from 2006 to 2016.

Small sized specimens traditionally dominate the rapido trawl landings (Figure 6.6.2.1.3). Italian set net fishery lands mostly the same portion of the population(Figure 6.6.2.1.4), while the otter trawl fishery, exploiting wider fishing grounds, shows a wider size distribution of the landings (Figure 6.6.2.1.5). In the eastern part of the basin, common sole is exploited mainly by Croatian set netters (using trammel net), and the landings composition, is dominated by adults (Figure 6.6.2.1.6).

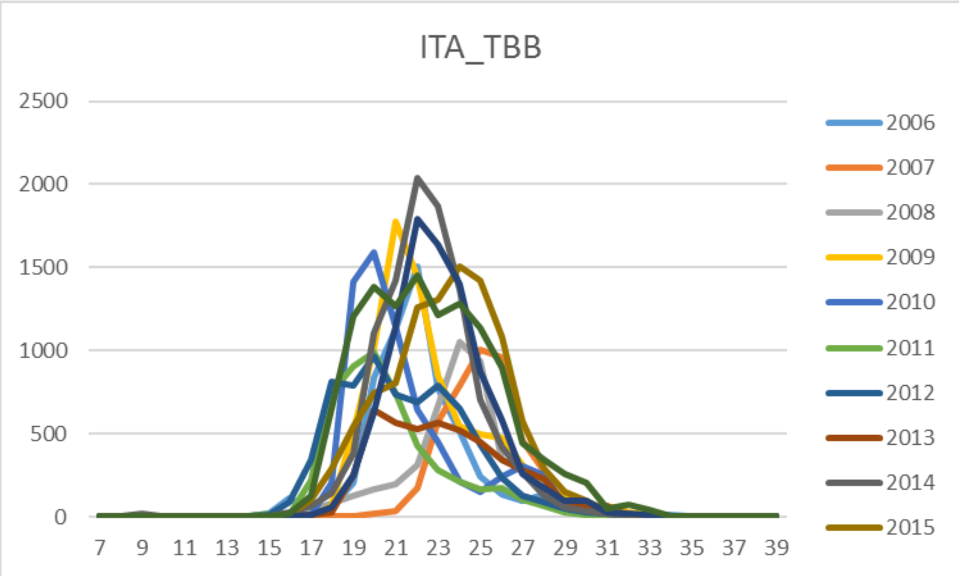


Figure 6.6.2.1.3. Sole in GSA 17 Size structure of the Italian TBB landings.

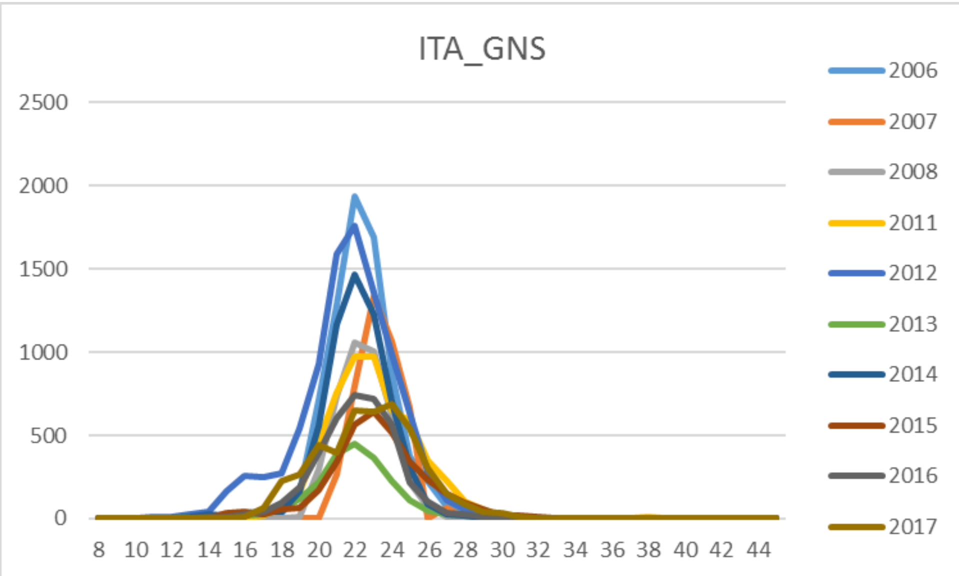


Figure 6.6.2.1.3. Sole in GSA 17 Size structure of the Italian GNS landings.

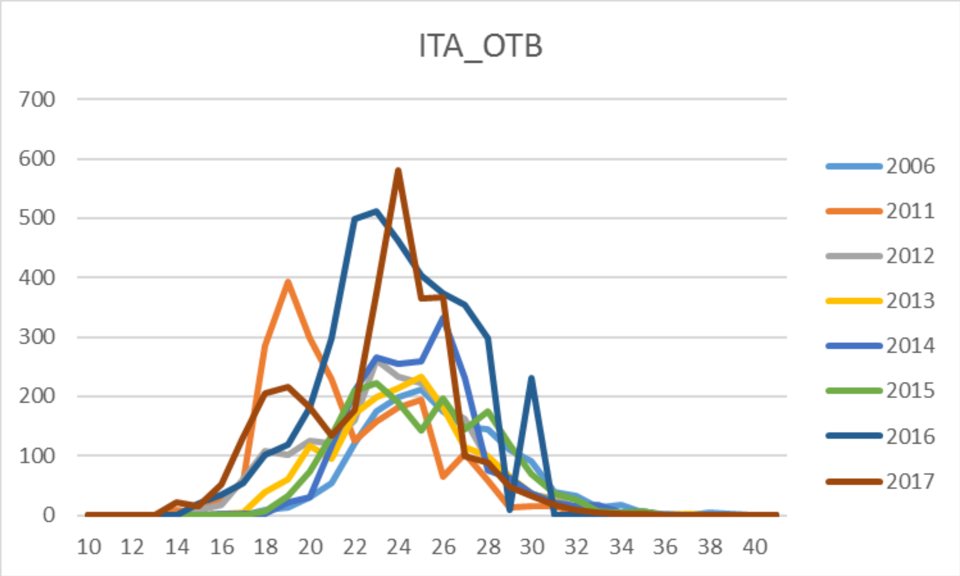


Figure 6.6.2.1.5. Sole in GSA 17. Size structure of the Italian OTB landings.

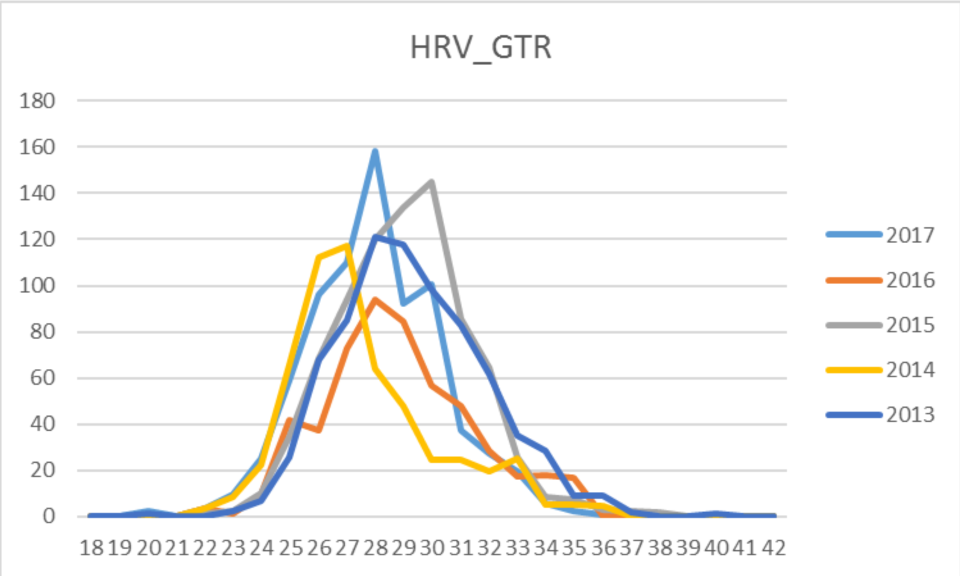


Figure 6.6.2.1.6. Sole in GSA 17. Size structure of the Croatian GTR landings.

For the assessment landings are assumed to be catch and the discards assumed negligible.

6.6.2.2 Effort

The effort data are available for GSA17. In Table 6.6.2.2.1 and in Figure 6.6.2.2.1 is reported the fishing effort by country for the main gears targeting this species in terms of GT*fishing days.

Table 6.6.2.2.1. Sole in GSA 17. Effort as GT*fishing days.

	GTR_HRV	GTR_SVN	GNS_ITA	OTB_ITA	TBB_ITA
2004	-	-	4476609	27823853	4232537
2005	-	61277	4980544	24094431	3812915
2006	-	54215	4315531	19896811	4946237
2007	-	122916	2538855	19409042	5231834
2008	-	120355	2451730	20038778	4136346
2009	-	121257	3280887	18889991	4386154
2010	-	128200	3396375	18094570	3817491
2011	-	171764	4643321	16572093	2584717
2012	2170478	166635	5314329	14020762	3254187
2013	2342614	241785	2974353	12614324	2769675
2014	2084672	195063	3864370	14435027	3729815
2015	2312695	188255	2903140	13847944	3448162
2016	1960112	160231	3670471	14195449	3307483
2017	2102611	123514	1899953	16508622	3328623

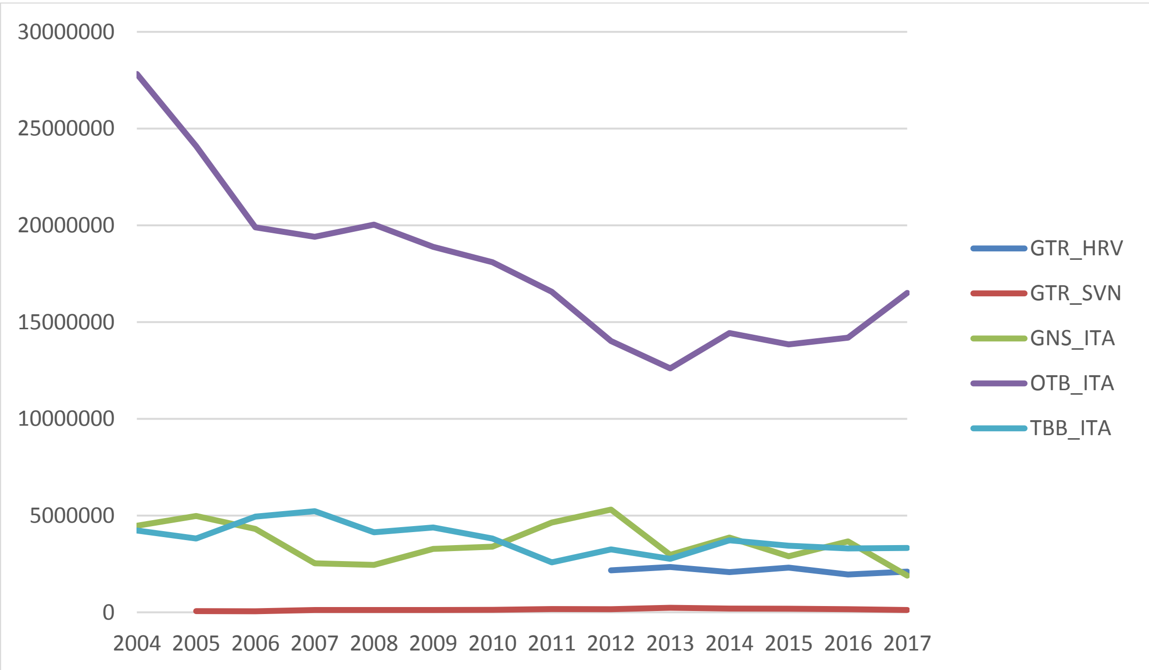


Figure 6.6.2.2.1. Sole in GSA 17. Effort by country and by gear expressed in GT*fishing days.

6.6.2.3 Survey data

With reference to the SoleMon project, different rapido trawl fishing surveys were carried out in GSA 17 during 2005 to 2017: two systematic "pre-surveys" (spring and fall 2005), these were followed by random haul location surveys in spring and fall 2006, and then a sequence of fall surveys 2007-2016). The surveys were random stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). Hauls were carried out by day using 2-4 rapido trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83).

Abundance and biomass indexes from rapido trawl surveys were computed using ATrIS software (Gramolini et al., 2005) which also allowed drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles.

The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as standard deviation.

Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA.

Figures 6.6.2.3.1 and 6.6.2.3.2 show the abundance and biomass indices respectively of sole obtained from 2006 to 2017; increasing trends occurred from the beginning of the period observed, with a peak in 2014 followed by a decrease in the last three years.

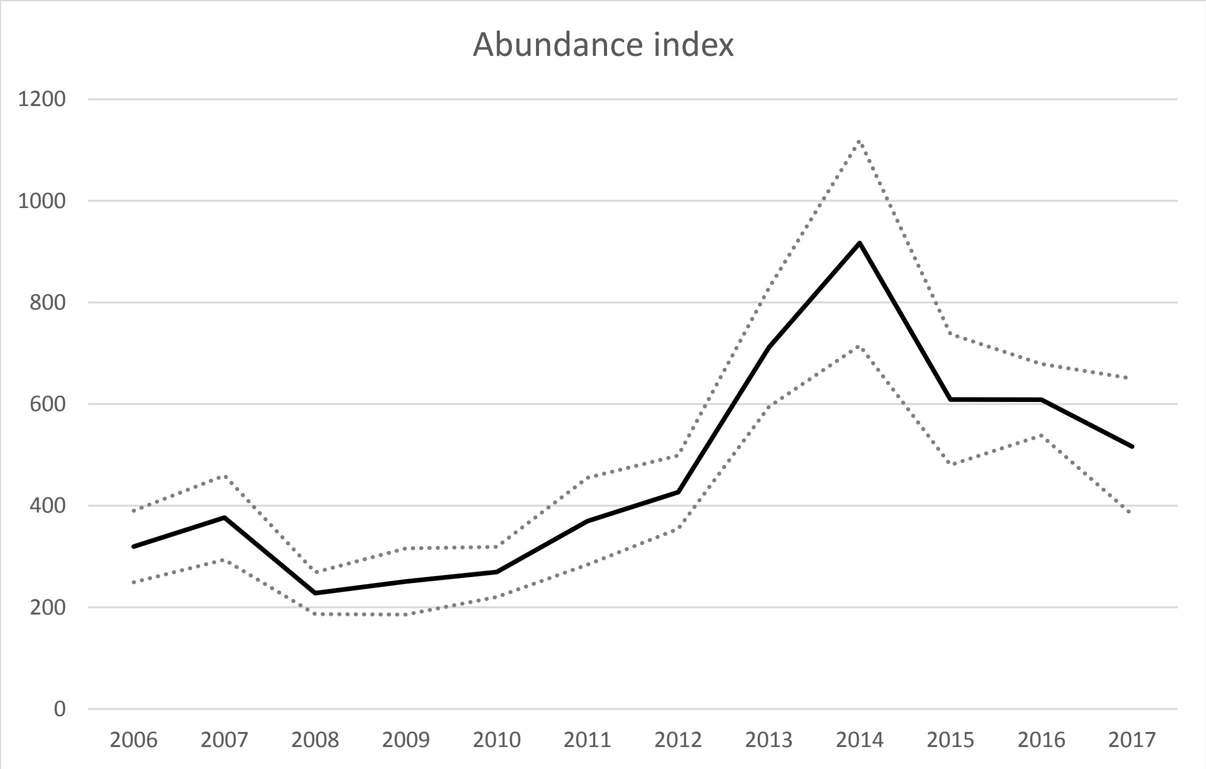


Figure 6.6.2.3.1. Sole in GSA 17. Abundance index from Solemon survey.

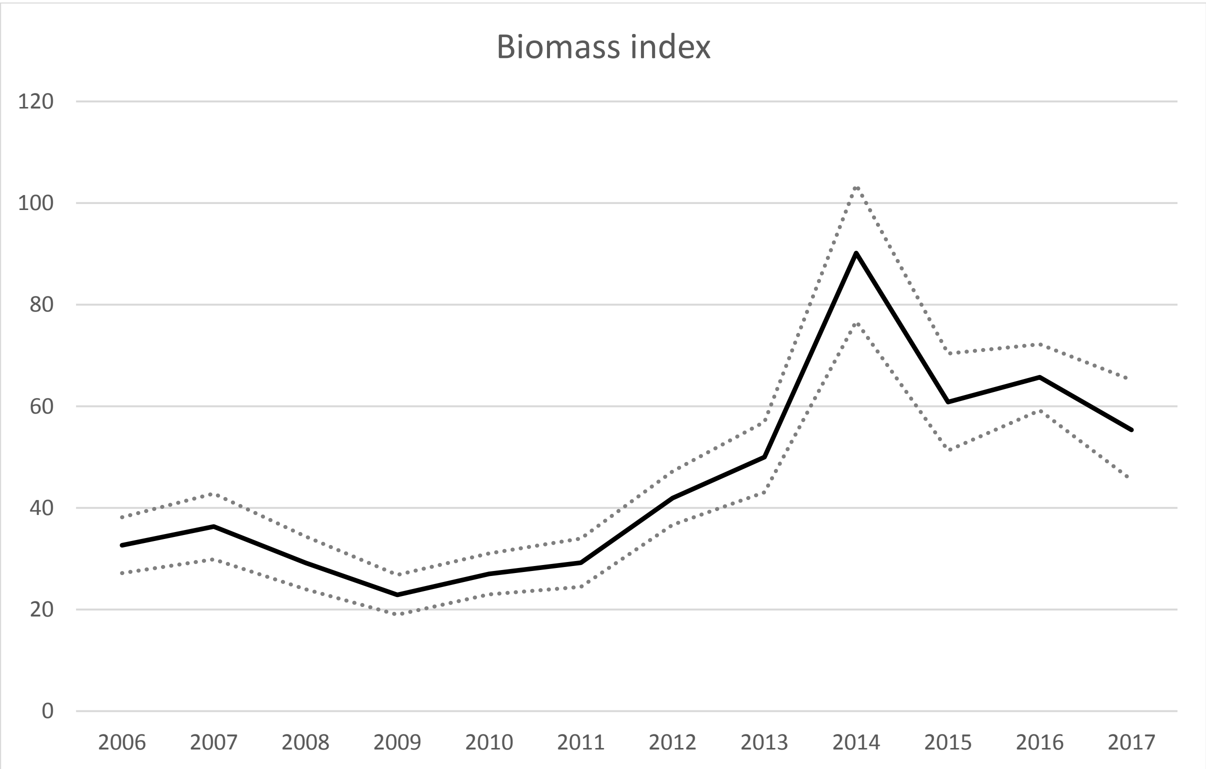


Figure 6.6.2.3.2. Sole in GSA 17. Biomass index from Solemon survey.

6.6.3 STOCK ASSESSMENT

The common sole stock in GSA 17 was assessed during the EWG 18-16 using two age based methods: Stock Synthesis 3 (SS3) and Assessment for All (a4a).

6.6.3.1 SS3 ASSESSMENT

A statistical catch-at-age assessment was carried out for this stock, using the Stock Synthesis method (Methot and Wetzel, 2013). Stock Synthesis 3 provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. It is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analysed. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity and calculates abundance forward in time, allowing for errors in the catch at age matrices. Selectivity has been generated as age-specific by fleet, with the ability to capture the major effect of age-specific survivorship.

Input data

The assessment was carried out considering the period 1980-2017 for catch data and 2005-2017 for tuning data. Catch data presented for the period 1980 – 2005 came from FAO-Fishstat source; catch data for the period 2006-2012 for Croatian and Slovenian trammel nets were a combination of DCF and FAO Fishtat – Primo Project data (Table 6.6.3.1.1).

Table 6.6.3.1.1. Sole in GSA 17. Catch data by fishing fleets from different sources.

Total catch/year				
year	**GNS Italy**	**TBB+OTB Italy**	**GTR HRV+SVN**	**Total GSA17**
1980	694	1233	308	2235
1981	348	620	155	1123
1982	377	669	167	1213
1983	513	911	228	1652
1984	440	781	195	1416
1985	480	854	213	1547
1986	494	878	220	1592
1987	823	1464	366	2653
1988	619	1101	275	1995
1989	586	1043	261	1890
1990	383	682	170	1235
1991	365	650	162	1177
1992	590	1048	262	1900

1993	625	1110	278	2013
1994	711	1265	316	2292
1995	612	1087	272	1971
1996	379	673	168	1220
1997	388	690	172	1250
1998	367	653	163	1183
1999	397	705	176	1278
2000	309	559	168	1036
2001	319	579	206	1104
2002	298	539	238	1075
2003	633	1147	327	2107
2004	561	1015	246	1822
2005	594	1075	325	1994
2006	717	1106	199	2022
2007	466	913	209	1588
2008	410	775	140	1325
2009	509	1134	311	1954
2010	520	901	193	1614
2011	625	706	258	1589
2012	781	906	172	1859
2013	207	793	253	1253
2014	562	1350	136	2048
2015	388	1469	188	2045
2016	388	1588	117	2093
2017	485	1612	160	2257

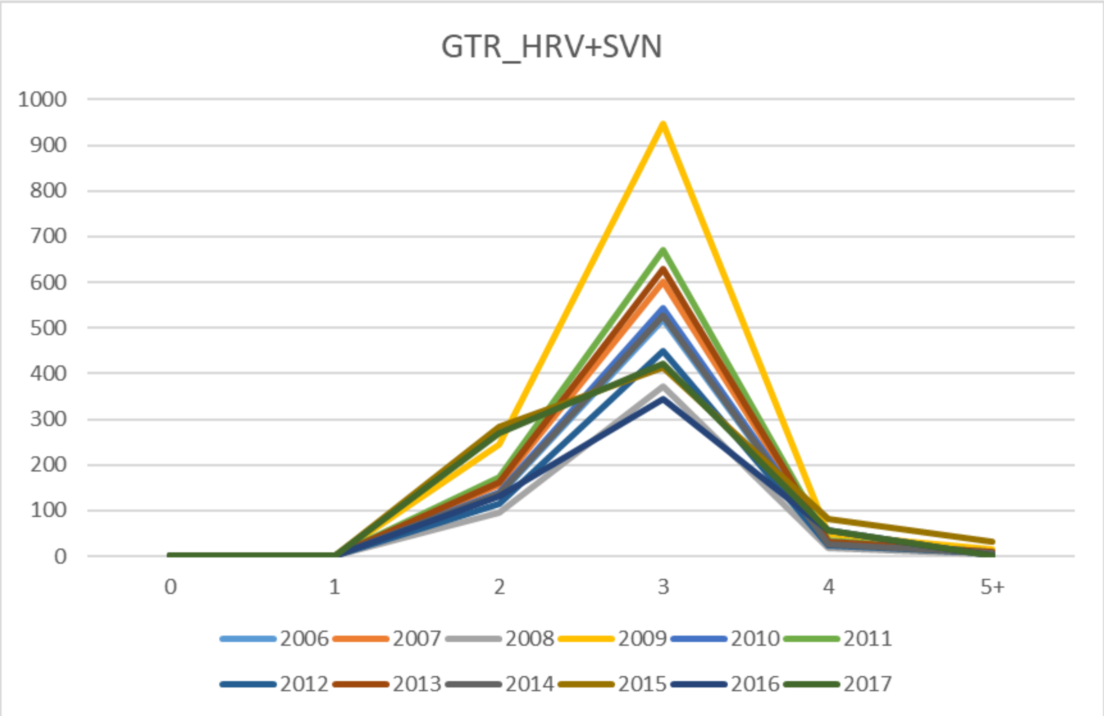
DCF
FAO Fishstat
Combined DCF (for SVN)/FAO Fishstat-Primo Project (for HRV)

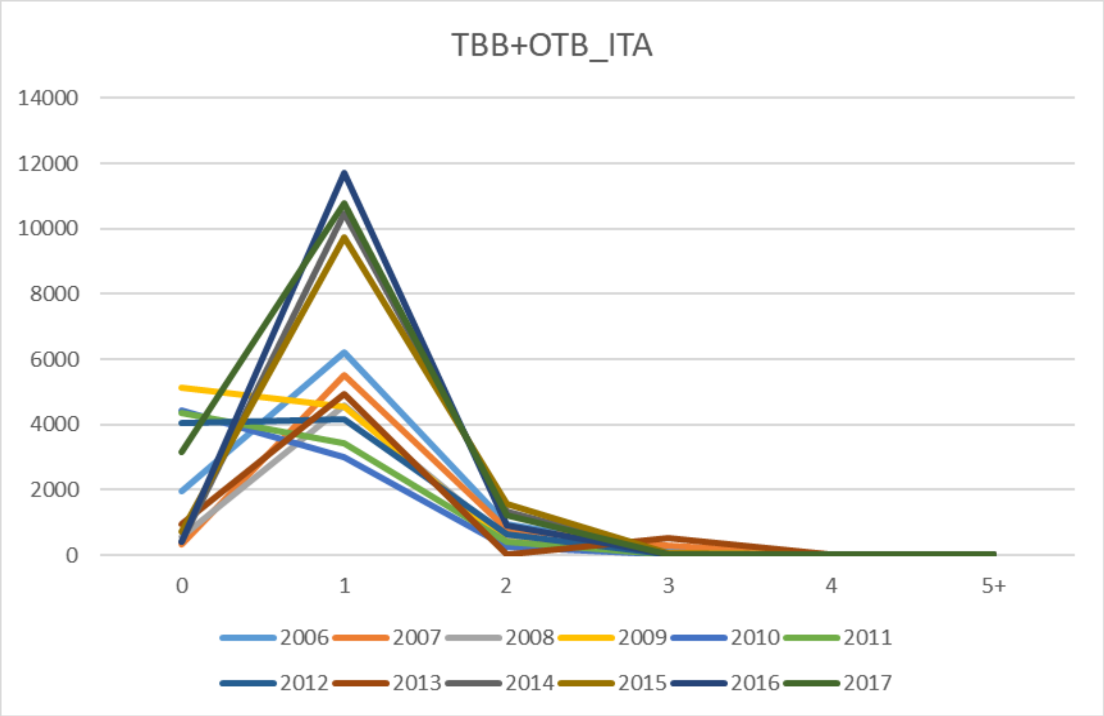
Catch numbers at age were those provided within the DCF for GSA 17 and they were the results of otoliths reading (Table 6.6.3.1.2 and Figure 6.6.3.1.1).

Table 6.6.3.1.2 Sole in GSA 17. Age structure of the catch in 2006-2017 by fleet (numbers in thousands).

	GTR_Croatia+Slovenia					
Year	Age0	Age1	Age2	Age3	Age4	Age5+
2006	0	0	134	518	27	8
2007	0	0	155	601	31	9
2008	0	0	96	373	19	5
2009	0	0	244	948	49	14
2010	0	0	140	544	28	8
2011	0	0	173	671	35	10
2012	0	0	116	449	23	6
2013	0	0	162	629	32	9
2014	0	0	136	526	27	8
2015	0	0	283	414	81	32
2016	0	0	130	344	56	0
2017	0	0	271	422	58	0
	TBB+OTB_Italy					
2006	1937	6215	958	119	0	0
2007	340	5528	802	288	1	1
2008	572	4603	474	63	0	1
2009	5112	4532	407	49	1	2
2010	4443	2985	248	37	1	1
2011	4358	3436	414	27	4	6
2012	4053	4152	642	24	0	0
2013	961	4935	22	513	0	0
2014	421	10462	1324	15	0	0
2015	698	9744	1554	59	0	0
2016	406	11703	894	2	0	0
2017	3163	10783	1211	24	0	0
	GNS_Italy					
2006	1017	4294	541	67	0	0
2007	90	2943	442	60	0	0
2008	298	2835	32	0	0	0

2009	855	3239	276	33	0	2
2010	873	3213	266	15	0	2
2011	815	3830	602	24	2	14
2012	4081	4906	272	2	0	0
2013	454	1618	1	31	0	0
2014	225	5336	345	2	0	0
2015	193	2829	356	13	0	0
2016	344	3620	78	1	0	0
2017	771	3576	228	2	0	0





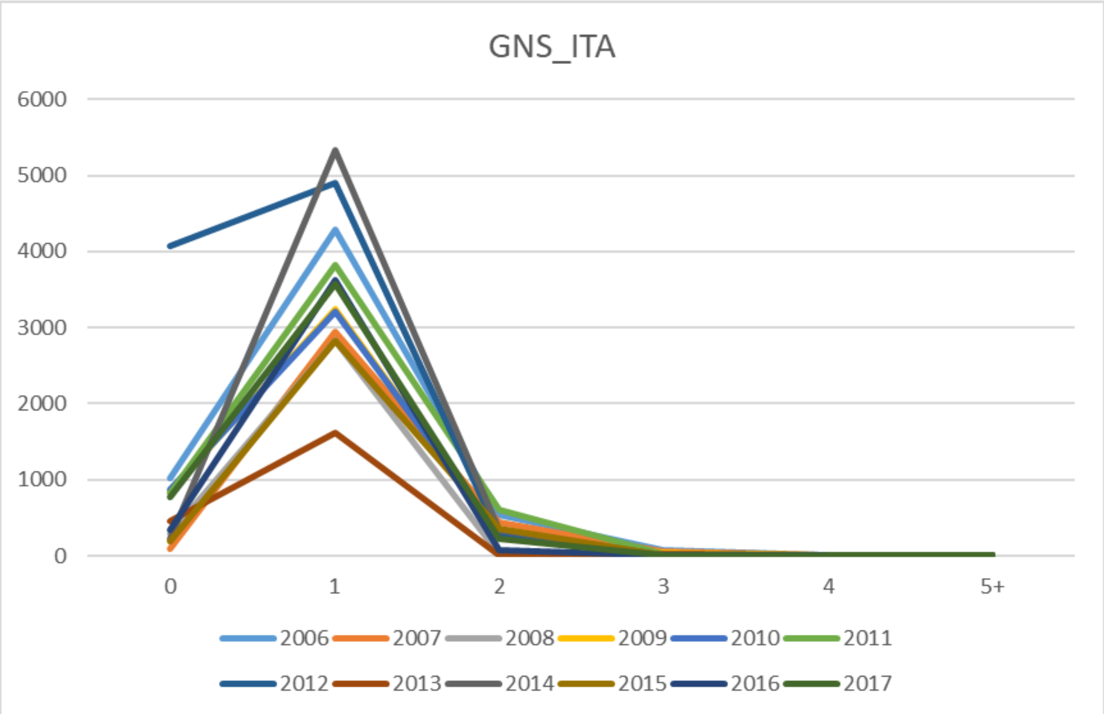


Figure 6.6.3.1.1 Sole in GSA 17. Age structure of the catch in 2006-2017 by fleet.

The individual weights at age for the catch and the stock are reported in Table 6.6.3.1.3. A vector of natural mortality at age was estimated using the PRODBIOM spreadsheet (Abella et al., 1997); the maturity at age vector was provided in the framework of SoleMon project (Tab. 6.6.3.1.4). The M and F before spawning were set equal to 0. A plus group was set at age 5. The Fbar considered was for ages 1-4.
Table 6.6.3.1.5 and figure 6.6.3.1.2 show the tuning series at age from the Solemon survey.

Table 6.6.3.1.3. Sole in GSA 17. Individual weight at age for the catch and for the stock (kg).

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5+
Catch mean weight	0.07	0.14	0.21	0.33	0.45	0.52
Stock mean weight	0.02	0.10	0.21	0.30	0.38	0.52

Table 6.6.3.1.4. Sole in GSA 17. Maturity and natural mortality vectors.

Maturity at age					
Age 0	Age 1	Age 2	Age 3	Age 4	Age 5+
0.00	0.16	0.76	0.96	0.99	1.00

Natural Mortality					
Age 0	Age 1	Age 2	Age 3	Age 4	Age 5+
0.70	0.35	0.28	0.25	0.23	0.22

Table 6.6.3.1.5. Sole in GSA 17. Numbers at age from Solemon survey (n/km^2).

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5+
2005	89.8	123.6	53.2	9.9	4.7	0.6
2006	56.8	171.3	82.3	8.3	0.8	0.2
2007	74.8	195.4	75.0	27.8	3.1	0.6
2008	24.0	109.9	72.4	14.9	5.3	1.4
2009	72.7	107.0	60.4	7.7	2.9	0.2
2010	15.7	200.0	41.2	9.1	1.3	2.2
2011	68.1	246.5	45.0	7.7	1.4	0.9
2012	52.1	254.5	107.0	10.6	2.6	0.0
2013	181.6	421.4	90.6	14.9	3.2	0.0
2014	75.7	608.2	213.4	15.0	4.6	0.3
2015	227.0	242.7	123.0	12.8	1.3	4.2
2016	72.7	394.5	95.5	33.5	1.7	2.8
2017	139.5	251.4	106.7	17.7	1.4	0.0

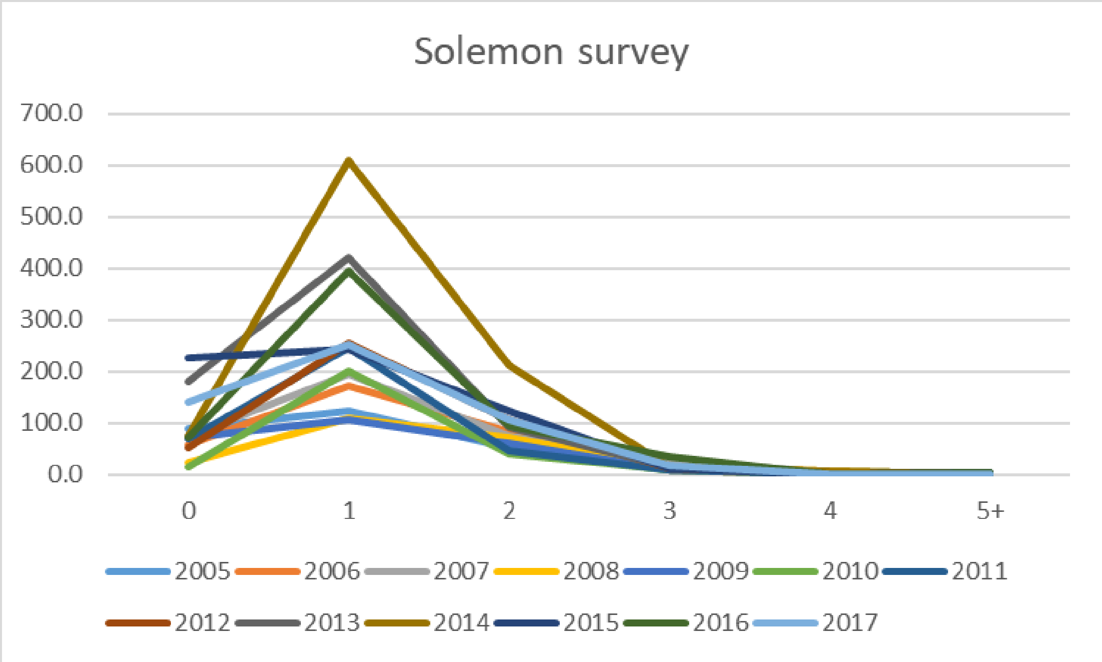


Figure 6.6.3.1.2. Sole in GSA 17. Age structure of the sole in the survey 2005-2017.

As the model described below was an update of the one carried out during the STECF EWG 17-15, it assumed a logistic selectivity pattern for the survey and a double normal selectivity pattern for commercial fleets, with the only constraint to be constant from age 4 (Figure 6.6.3.1.3).

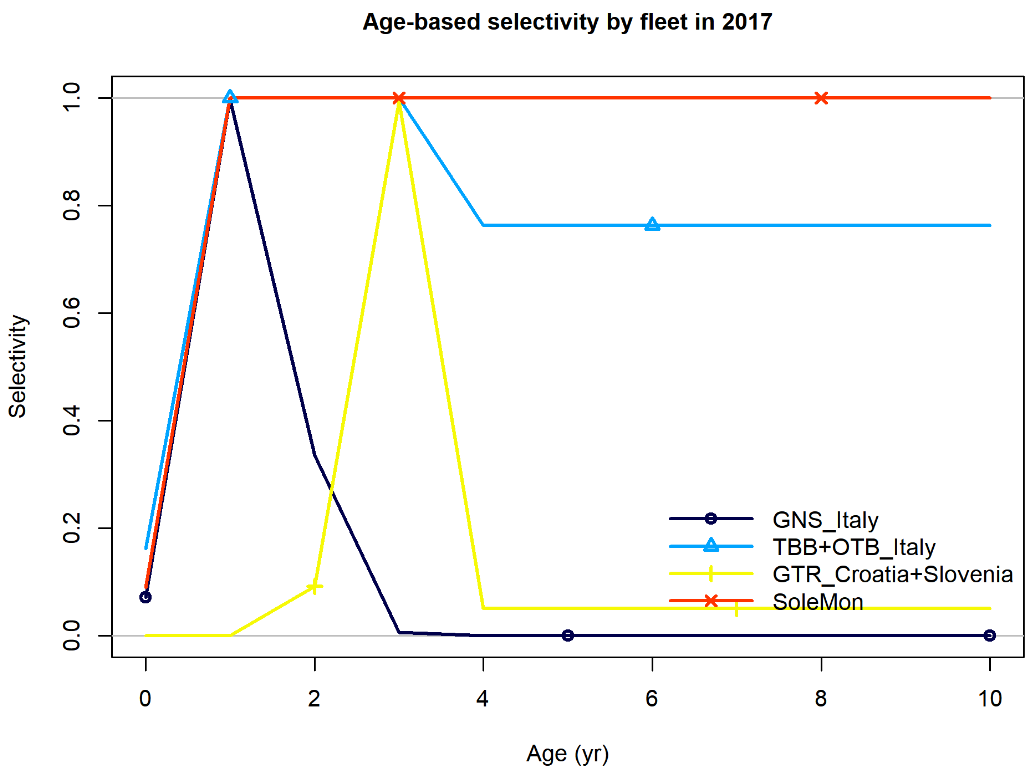


Figure 6.6.3.1.3. Sole in GSA 17. Selectivity by age used in the SS3 model.

Assessment results

The results of the SS3 model are shown in Figures 6.6.3.1.4 - 6.6.3.1.7.

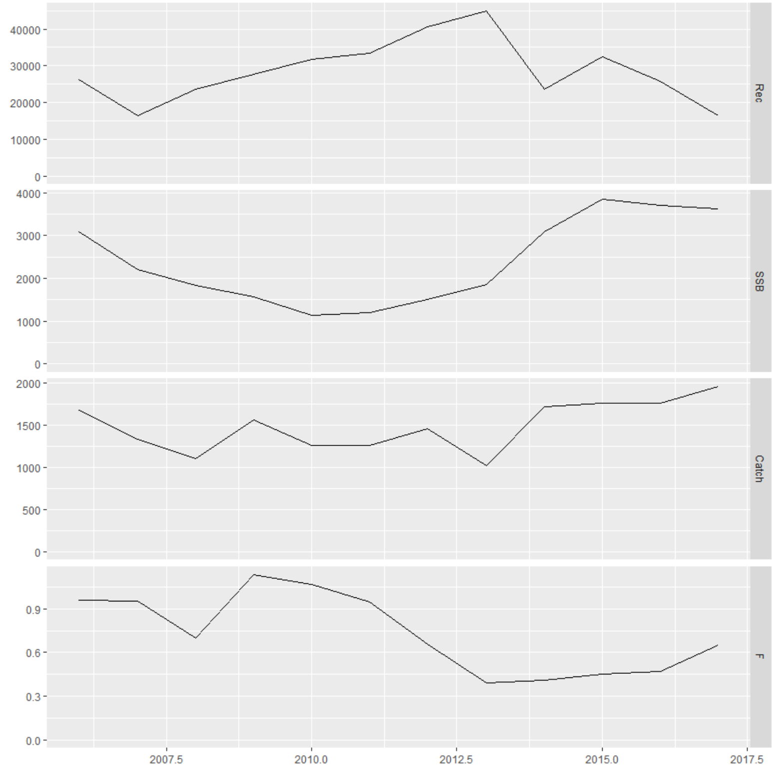


Figure 6.6.3.1.4. Sole in GSA 17. Stock summary from the SS3 model.

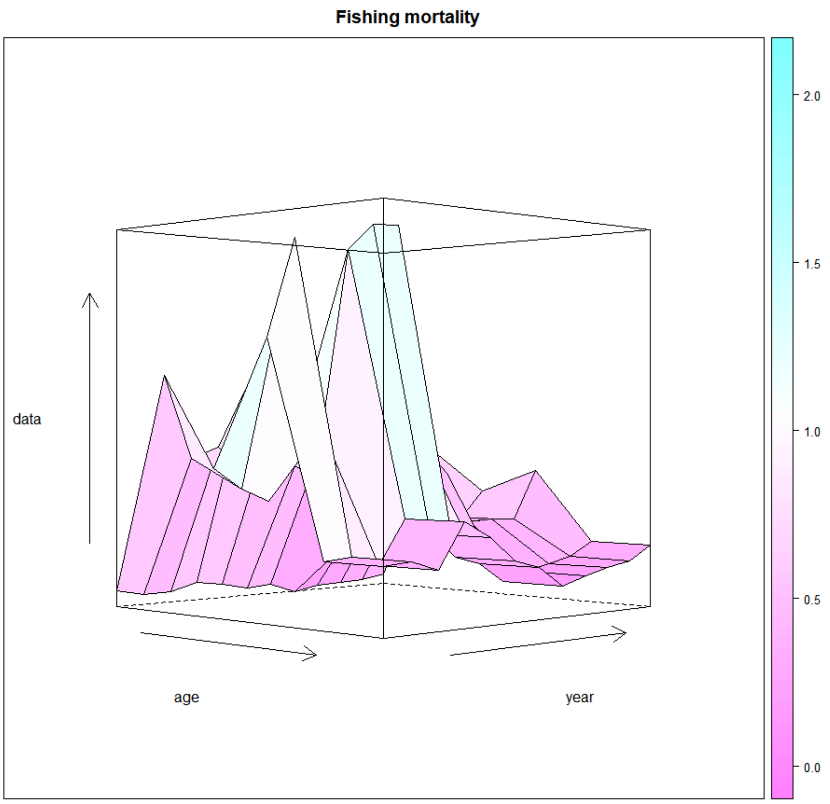


Figure 6.6.3.1.5. Sole in GSA 17. 3D contour plot of estimated fishing mortality at age and year.

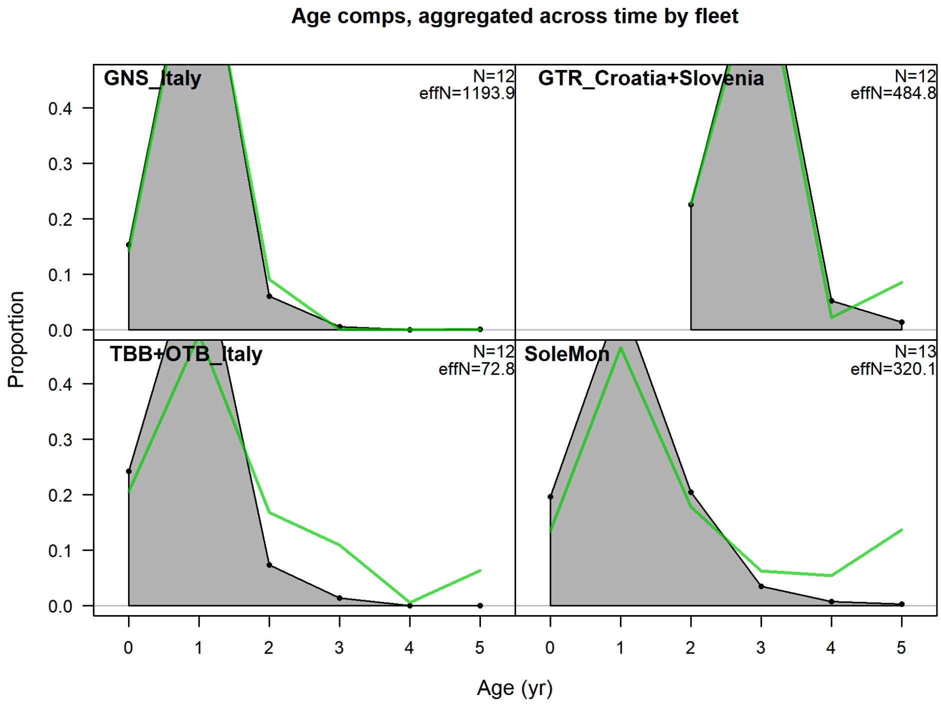


Figure 6.6.3.1.6. Sole in GSA 17. Observed and estimated age compositions from SS3 model.

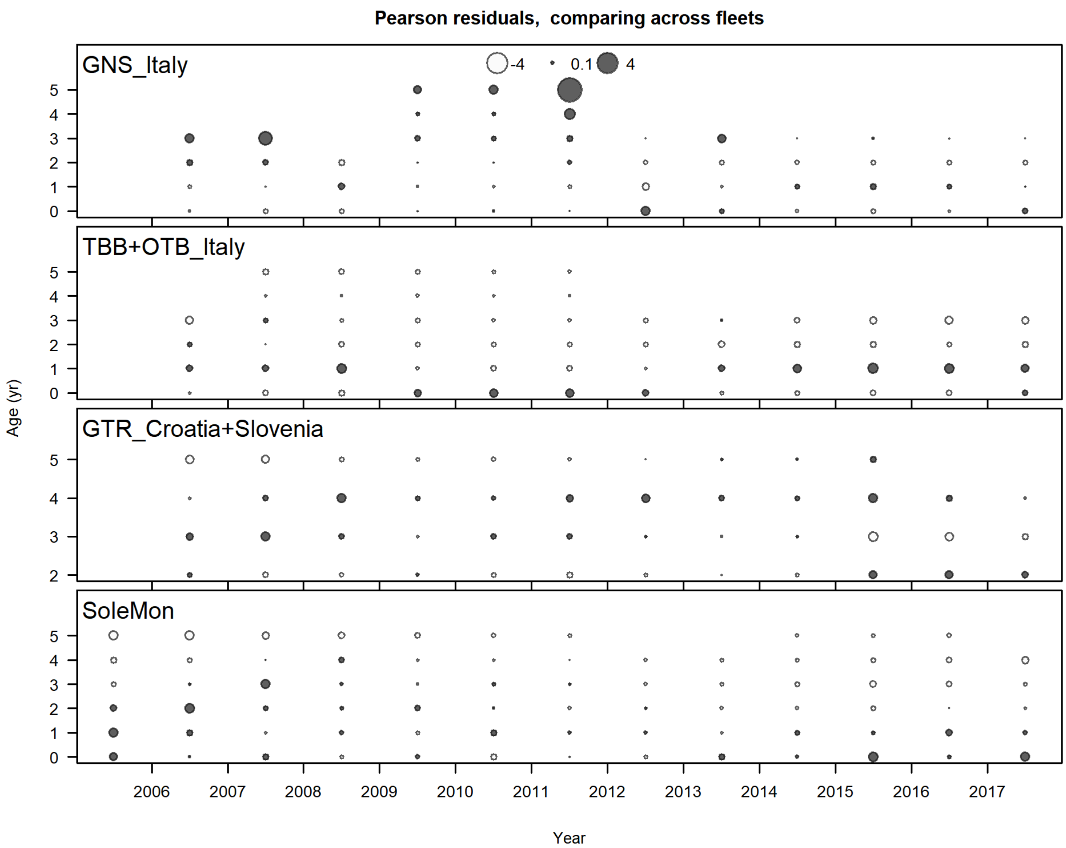
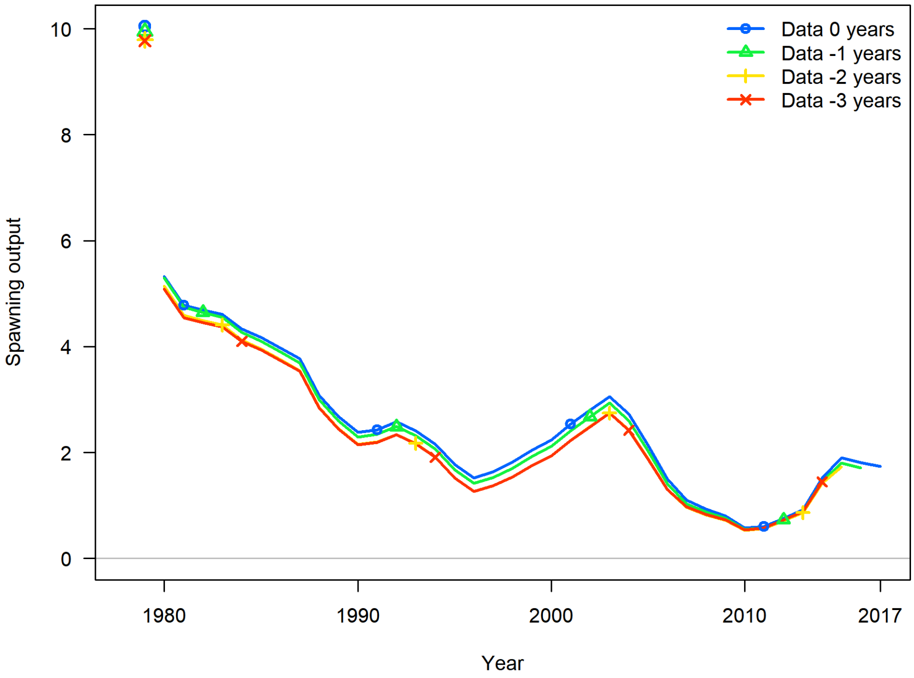
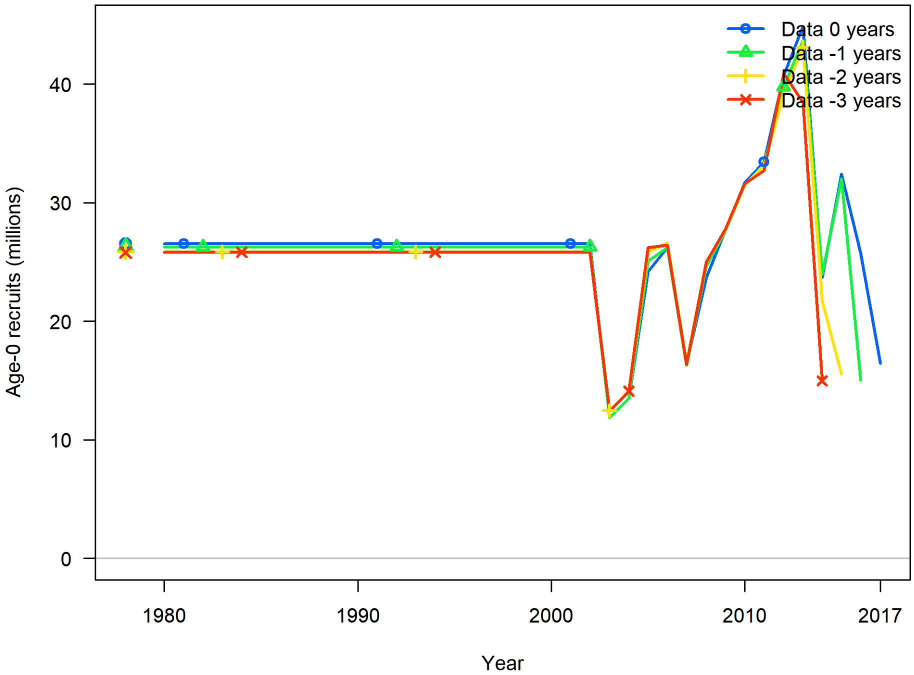


Figure 6.6.3.1.7. Sole in GSA 17. Pearson residuals from SS3 model.

The fitting on age compositions for the fleets and the survey was generally good, even if in some cases there was an overestimation of individuals al older ages, as confirmed by the Pearson residuals plot.
The retrospective analysis was applied up to 3 years back. Model results were stable, as shown in figure 6.6.3.1.8.





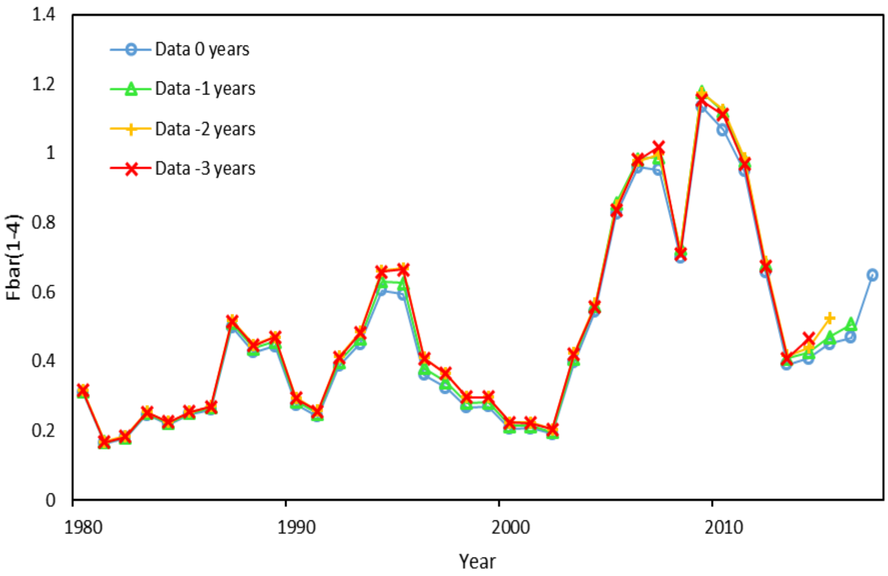


Figure 6.6.3.1.8. Sole in GSA 17. Retrospective analysis for SSB, Recruits and Fbar ages 1-4 from SS3 model.

In the following tables, the population estimates obtained by the SS3 model are provided.

Table 6.6.3.1.6. Sole in GSA 17. Results of the SS3 model: Stock numbers at age (thousands).

	0	**1**	**2**	**3**	**4**	**5+**
2006	26227.9	10542.5	1029.0	501.9	728.2	4129.7
2007	16425.4	11475.2	2119.4	353.5	93.7	2745.5
2008	23643.8	7420.2	3531.0	811.1	40.4	1598.2
2009	27720.8	10641.0	2157.6	1448.8	237.3	976.9
2010	31690.7	11953.7	2304.1	642.8	171.8	581.3
2011	33428.1	14019.1	3172.1	778.0	66.2	389.1
2012	40726.0	15234.2	4532.4	1263.0	79.6	266.3
2013	44877.4	18423.3	4561.2	1928.3	399.0	210.3
2014	23710.0	21347.3	9448.4	2542.8	713.1	402.4
2015	32419.0	11039.5	8910.2	4827.6	1224.9	704.4
2016	25738.4	14956.0	4284.9	4326.7	2302.1	1177.6
2017	16444.0	11812.0	5655.2	2020.0	2074.8	2067.0
2018	26536.4	7366.6	3547.2	2294.1	746.0	2289.5

Based on the SS3 model, the SSB shows a decreasing trend from 2006 to 2010, followed by an increase until 2015. In the last three years, the SSB is quite stable with around

3600 tons in 2017. The F time series shows values ranging between 0.39 and 1.13. After a peak in 2009-2010 followed by a strong decrease, the F reaches a value of 0.65 in 2017. The recruitment does not show any evident trend (Table 6.6.3.1.7). The fishing mortality at age peaks at ages 1 and 3 (Table 6.6.3.1.8).

Table 6.6.3.1.7. Sole in GSA 17. Results of the SS3 model: Fbar (1-4), SSB, recruitment and total biomass.

Year	Fbar (1-4)	Recruitment (thousands)	SSB (tons)	Total biomass (tons)	Catch (tons)
2006	0.96	26228	3005.6	4623.2	2022
2007	0.95	16425	2199.2	3713.8	1588
2008	0.7	23644	1856.4	3263.3	1325
2009	1.13	27721	1602.1	3330.0	1954
2010	1.07	31691	1142.2	3078.3	1614
2011	0.95	33428	1196.8	3401.0	1589
2012	0.66	40726	1507.7	4067.8	1859
2013	0.39	44877	1842.7	4793.8	1253
2014	0.41	23710	3039.4	5992.8	2048
2015	0.45	32419	3797.7	6055.6	2045
2016	0.47	25738	3626.4	5835.6	2093
2017	0.65	16444	3467.2	5216.7	2257

Table 6.6.3.1.8. Sole in GSA 17. Results of the SS3 model: F at age.

	0	1	2	3	4	5+
2006	0.13	1.25	0.79	1.43	0.37	0.37
2007	0.09	0.83	0.68	1.92	0.38	0.38
2008	0.10	0.89	0.61	0.98	0.33	0.33
2009	0.14	1.18	0.93	1.88	0.55	0.55
2010	0.12	0.98	0.81	2.02	0.47	0.47
2011	0.09	0.78	0.64	2.03	0.34	0.34
2012	0.09	0.86	0.57	0.90	0.30	0.30
2013	0.04	0.32	0.30	0.74	0.20	0.20
2014	0.06	0.52	0.39	0.48	0.24	0.24
2015	0.07	0.60	0.44	0.49	0.27	0.27

2016	0.08	0.62	0.47	0.48	0.30	0.30
2017	0.10	0.85	0.62	0.75	0.37	0.37

6.6.3.2 Assessment for all (a4a)

A4a is a flexible statistical catch at age stock assessment method, implemented in R/FLR/ADMB (Jardim et al., 2015). The model structure is defined by sub-models, which are based on linear modelling techniques.

Input data

Total landings combined for the whole of GSA 17 are reported in Table 6.6.3.2.1. Tuning data were provided by SoleMon surveys, carried out in fall for the years 2006-2017.

As this analysis was run to account for the ageing issues detected in the otholith readings, length frequencies distributions from official DCF 2018 and Solemon surveys were used as input in the slicing procedure to obtain age matrices. Slicing procedures were based on the growth parameters reported in Table 6.6.1.1. The slicing procedure was ran also with a negative t0 of -0.42 (the corresponding negative value of 0.58) to test if age matrices obtained from a negative t0 would impact the assessment results. As no difference was detected in the ratio of Fcurrent/F0.1 obtained at the end of the assessment, only the results for the positive t0 growth parameters combination is reported in this report.

The catch at age matrix and the tuning index at age matrix are reported in Table 6.6.3.2.2 and Table 6.6.3.2.3 respectively.

The individual weights at age for the catch are reported in Table 6.6.3.2.3.

Maturity at age (Tab. 6.6.3.2.4), Length-Weight relationships, growth parameters were obtained as explained in section 6.6.1. A vector of natural mortality rate at age was estimated using the PRODBIOM spreadsheet (Abella et al., 1997) (Tab. 6.6.3.2.5). The M and F before spawning were set equal to 0 as spawning occurs in the winter and birth date is set to January. A plus group was set at age 5. The Fbar used was for ages 1-3.

Table 6.6.3.2.1. Sole in GSA 17. Total catches used in the a4a assessment. Weights are expressed in tons

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total catches (t)	2021	1367	1126	1161	858	1519	1859	1859	1193	2057	2038	2261

Table 6.6.3.2.2. Sole in GSA 17. Catches at age, numbers in thousands.

	Age 1	**Age 2**	**Age 3**	**Age 4**	**Age 5+**

2006	141	12580	2544	513	133
2007	0	4020	3723	495	133
2008	15	4376	2607	350	99
2009	0	5101	2296	442	122
2010	133	4462	1608	267	75
2011	73	9752	2556	304	106
2012	568	12840	2650	271	69
2013	56	5403	2499	411	98
2014	121	12987	2997	189	77
2015	86	8768	5012	550	72
2016	100	11088	3719	455	63
2017	113	11945	4852	504	83

Table 6.6.3.2.2. Sole in GSA 17. Survey index, numbers in thousands.

	Age 1	**Age 2**	**Age 3**	**Age 4**
2006	45	184	82	8
2007	49	221	75	28
2008	14	120	72	15
2009	52	128	60	8
2010	9	211	37	8
2011	44	268	45	7
2012	34	284	108	9
2013	127	496	90	11
2014	39	661	199	14
2015	99	320	163	23
2016	25	423	141	16
2017	62	286	138	26

Table 6.6.3.2.3. Sole in GSA 17. Individual weight at age for the catch (kg).

	Age 1	Age 2	Age 3	Age 4	Age 5+
2006	0.04	0.11	0.19	0.29	0.39
2007	0	0.12	0.18	0.29	0.4
2008	0.04	0.11	0.19	0.29	0.41
2009	0	0.11	0.19	0.29	0.4
2010	0.04	0.1	0.19	0.29	0.4
2011	0.04	0.09	0.18	0.29	0.41
2012	0.04	0.1	0.18	0.29	0.39
2013	0.03	0.1	0.19	0.29	0.39
2014	0.03	0.11	0.18	0.29	0.38
2015	0.04	0.11	0.18	0.29	0.39
2016	0.04	0.11	0.18	0.28	0.39
2017	0.04	0.1	0.18	0.28	0.38

Table 6.6.3.2.4. Sole in GSA 17. Maturity at age.

Age 1	Age 2	Age 3	Age 4	Age 5+
0	0.47	1.00	1.00	1.00

Table 6.6.3.2.5. Sole in GSA 17. Mortality at age.

Age 1	Age 2	Age 3	Age 4	Age 5+
0.84	0.37	0.29	0.25	0.23

Different combinations of F and q , sr and v sub-models were explored. The best model (reported below) was chosen on the basis of the residuals and retrospective analysis.

f ~ factor(replace(age, age>4,4))+s(year, k=6)

q ~ list(~ factor(age))

sr ~ s(year, k=6)

v ~ list(~1, ~factor(age))

Results

The recruitment estimated by the a4a model shows a peak in 2013 of 40133 which results in a subsequent peak of SSB in 2014 of 5786 t and of estimated catch in 2014 of 3216 t. This is followed by a decrease in recruitment which seems to be bringing the stock back to values prior to 2011 (Figure 6.6.3.2.1 and Table 6.6.3.2.6). Last year estimated catch (1884 t) is, though, still higher than catches prior to 2011 (~1000 t). Consistently, fishing mortality has increased between 2012 and 2015, but despite the decrease in SSB and recruitment, catch has decreased further, so F has decreased as well from 2015 (Figure 6.6.3.2.1 and Table 6.6.3.2.6). Fishing mortality increases with age peaking at age 4 and 5 (Figure 6.6.3.2.2 and Table 6.6.3.2.7) showing the same shape of survey catchability which increases with age as well (Figure 6.6.3.2.2). F at age and Numbers at age are given in Table 6.6.3.2.7 and Table 6.6.3.2.8 respectively.

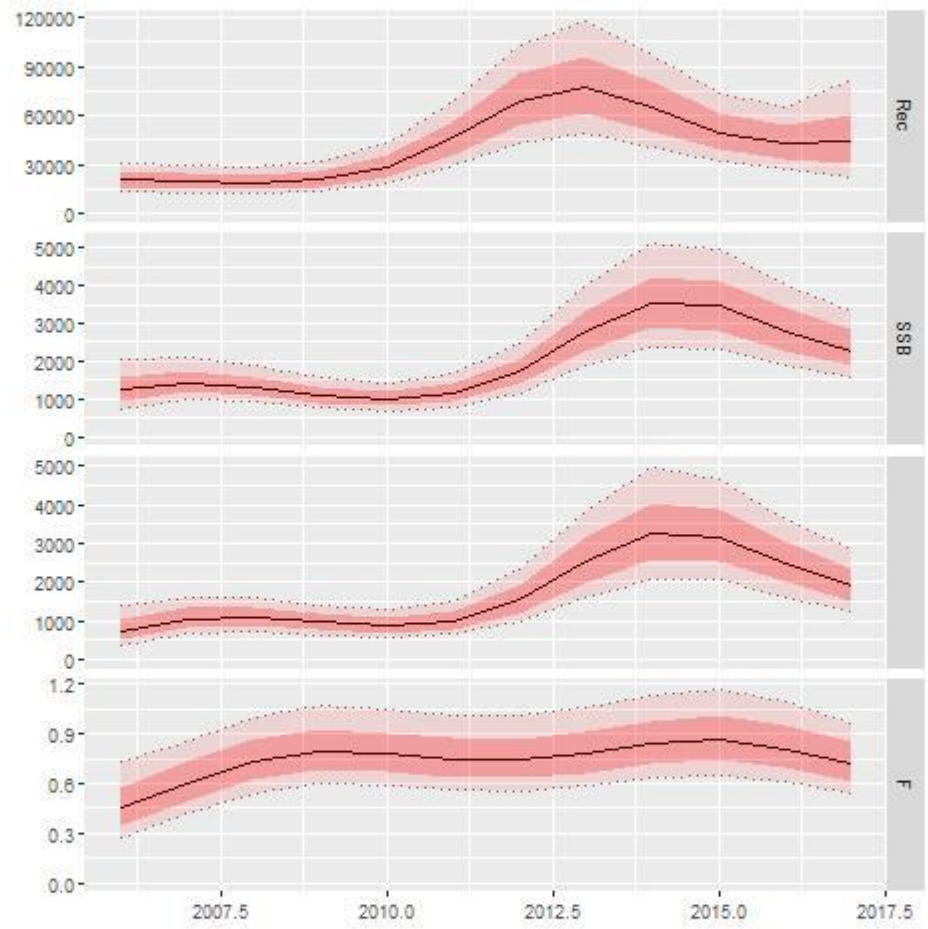
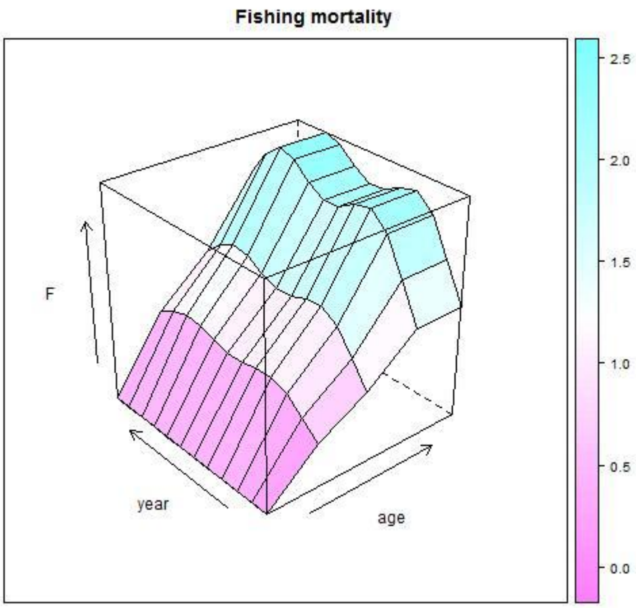


Figure 6.6.3.2.1 Sole in GSA 17. Stock summary from the results of the a4a model.

Table 6.6.3.2.6 Sole in GSA 17. Results of the final a4a run: Fbar (1-3), SSB, recruitment and estimated catch.

Year	Fbar (1-3)	Recruitment (thousands)	SSB (tons)	Total catch (tons)
2006	0.45	10479	1703	642
2007	0.6	9946	1813	1026
2008	0.74	9766	1991	1075
2009	0.8	10840	1449	947
2010	0.79	14804	1769	864
2011	0.75	23640	2290	987
2012	0.75	35514	3504	1496
2013	0.79	40133	4996	2480
2014	0.85	33451	5786	3216
2015	0.87	25353	5387	3118
2016	0.82	21947	4338	2442
2017	0.72	22288	3691	1884



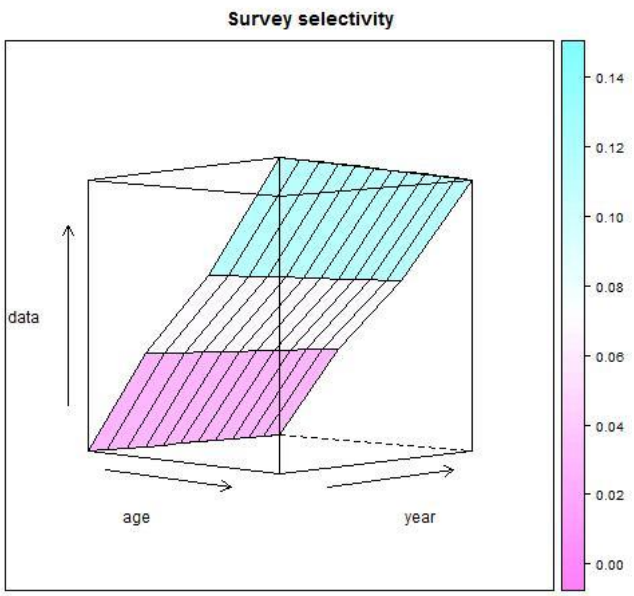


Figure 6.6.3.2.2 Sole in GSA 17. Fishing mortality (left) and survey catchability (right) by age and year.

Table 6.6.3.2.7 Sole in GSA 17. Results of the final a4a run: F at age.

	1	**2**	**3**	**4**	**5+**
2006	0	0.53	0.82	1.27	1.27
2007	0	0.71	1.1	1.69	1.69
2008	0	0.87	1.35	2.08	2.08
2009	0	0.95	1.46	2.25	2.25
2010	0	0.93	1.43	2.21	2.21
2011	0	0.88	1.37	2.11	2.11
2012	0	0.88	1.36	2.1	2.1
2013	0	0.93	1.44	2.21	2.21
2014	0	1	1.54	2.38	2.38
2015	0	1.02	1.58	2.43	2.43
2016	0	0.96	1.49	2.29	2.29
2017	0	0.85	1.32	2.03	2.03

Table 6.6.3.2.8 Sole in GSA 17. Results of the final a4a run: Numbers at age.

	1	**2**	**3**	**4**	**5+**
2006	6	2461	1457	137	174
2007	8	3612	1849	751	80
2008	9	3936	2055	656	132
2009	11	4066	1724	521	81
2010	15	4459	1559	373	50
2011	23	5912	1723	345	37
2012	34	9409	2448	416	37
2013	40	14624	4030	607	45
2014	36	17261	5960	923	58

2015	28	14591	6355	1196	73
2016	23	10667	5036	1196	88
2017	21	8557	3821	1027	100

The fitting of the commercial catch at age and the estimated indices are generally good, except for a slight overestimation of the catches in the years 2006-2012, which than switches to an underestimation up to 2015 (Figure 6.6.3.2.3). The residuals of the abundance index are generally low (between -3 and 3) and don't show particular patterns (Figures 6.6.3.2.4-6). The residuals of the catch data are generally low as well (between -3 and 3) but show a pattern that was not possible to account for in the model before 2012 and after 2013 (Figures 6.6.3.2.4-6).

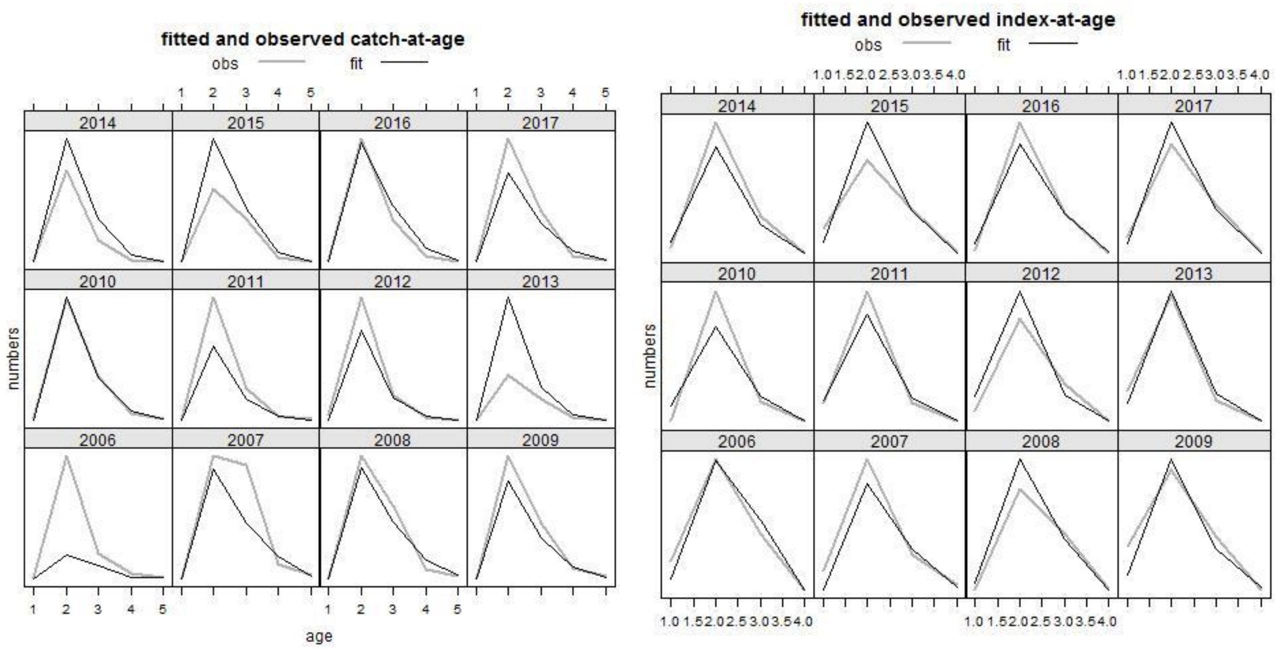


Figure 6.6.3.2.3 Sole in GSA 17. Comparison between fitted and observed catch (left) and index (right).

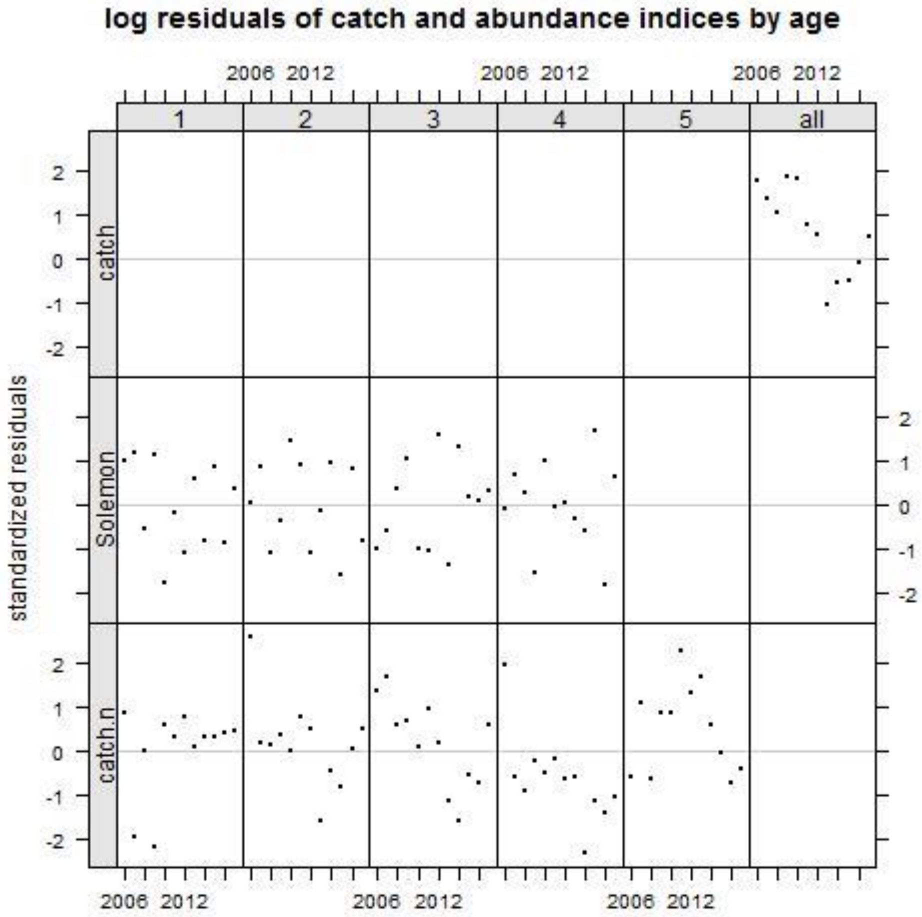


Figure 6.6.3.2.4 Sole in GSA 17. Log residuals of catch and abundance index by age.

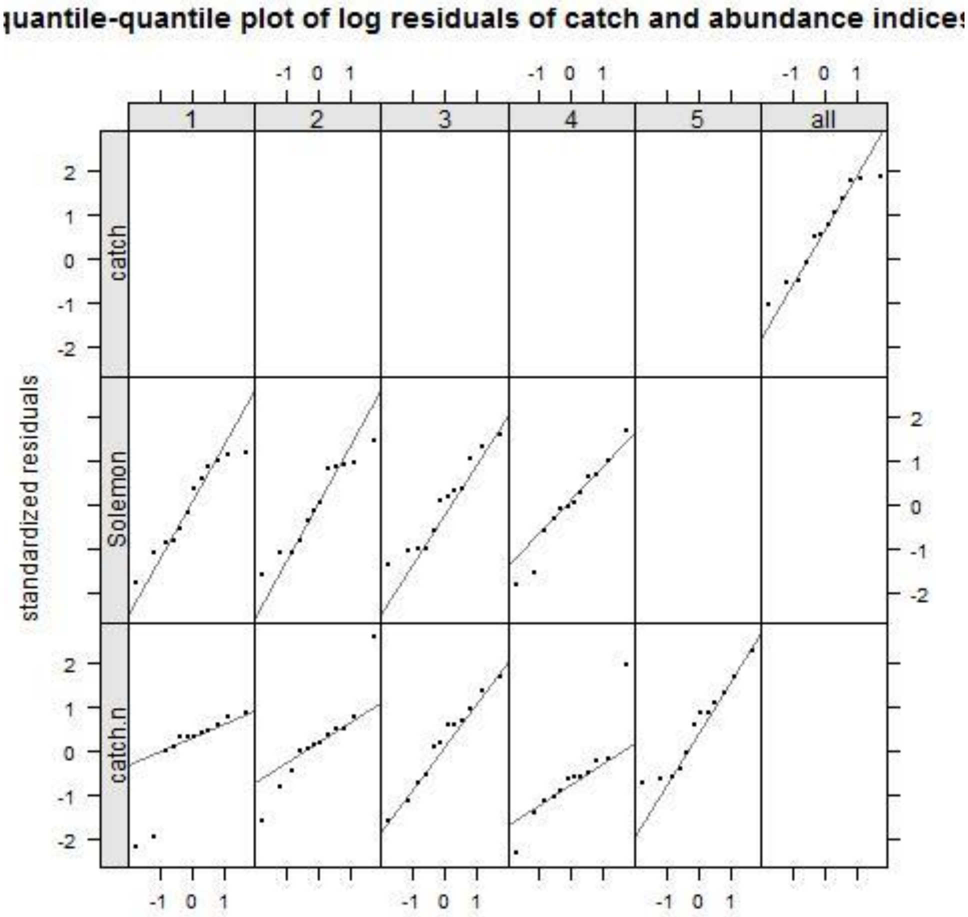


Figure 6.6.3.2.5 Sole in GSA 17. Quantile-quantile plot of catch and abundance index by age.

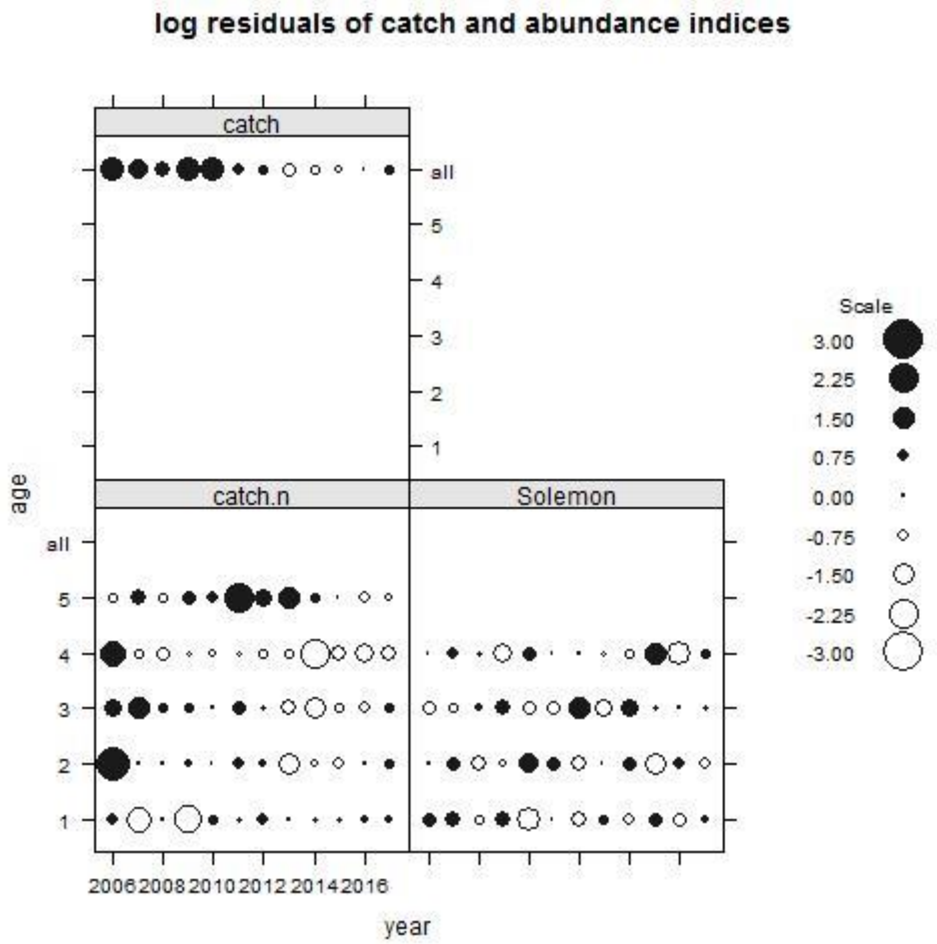


Figure 6.6.3.2.6 Sole in GSA 17. Bubble plot of the residuals of catch and abundance index by age.

The retrospective analysis was applied only to 1 year back due to model non-convergence if a higher number of years was taken from the time series. The short time series and the use of smoothers in the modelling framework can explain the lack of convergence during the retrospective analysis. The 1 year retrospective analysis though shows no instability (Figure 6.6.3.2.7).

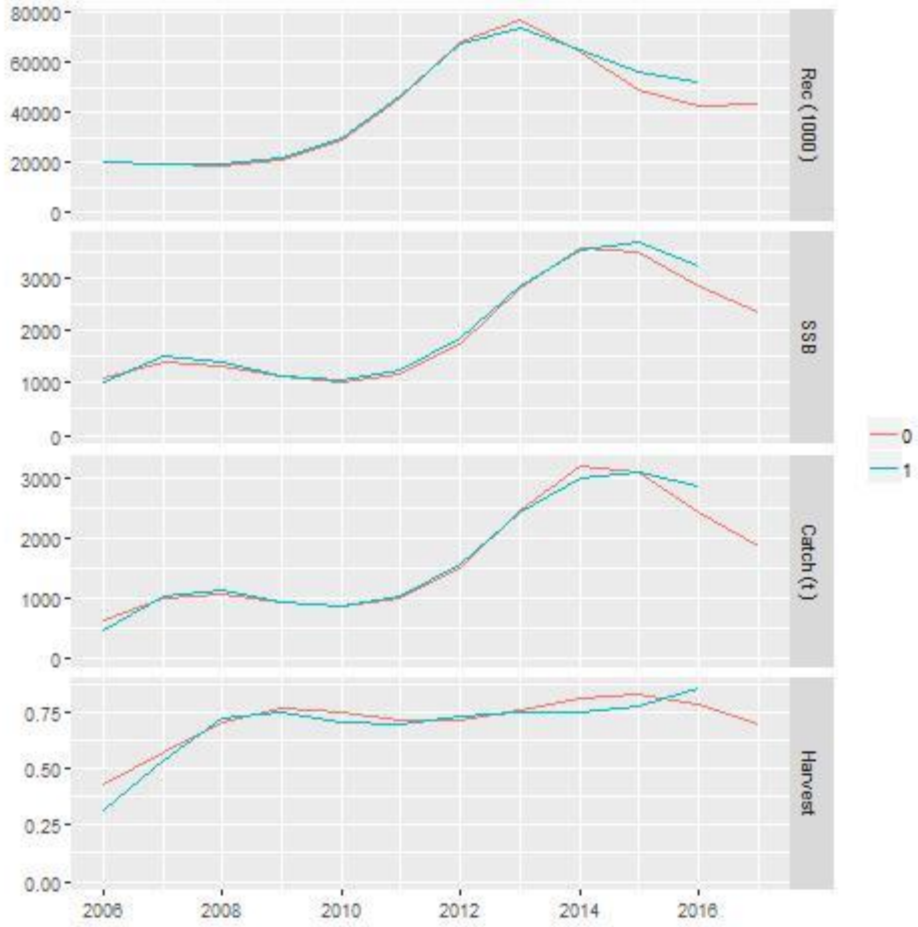


Figure 6.6.3.2.7 Sole in GSA 17. Retrospective analysis.

In order to account for the effect of uncertainty in age estimation described in section 6.6.1.2, we modelled the final a4a model introducing uncertainty around growth parameters, describing the Von Bertalanffy growth curve, using a multivariate normal distribution (Figure 6.6.3.2.8). While t0 and Linf were kept almost fix using a CV of only 0.01 to define their distribution, to define k a CV of 0.2 was applied in order to keep the process as uninformative as possible as no information on estimated uncertainty around the k parameter was available.

The obtained distributions were than used to generate 1000 simulated age matrices within which the abundance distribution among age classes would vary depending on the growth parameter used. This would produce a stock and an index objects made of 1000 iterations each, which were than used to rerun the a4a model once for each iteration. The results show how how uncertainty around the growth parameters affects mainly the estimate of fishing mortality among the outputs (Figure 6.6.3.2.9), suggesting that considering uncertainty is crucial when the age estimation process is uncertain.

Conclusions to the assessments.

The EWG received official data based on aged individuals on the same basis as 2017 assessment. The EWG was aware of revisions to this data being considered imminently. The EWG compared growth model based methods with the age data and concluded they were different, and the growth implied by the age data did not match the very obvious growth rates seen in the survey data. There was insufficient time to develop a full length based assessment, but age slicing approach, used for many other stocks, appears to be particularly effective for sole in GSA 17, so this was implemented using published growth curves. The uncertainty in the growth parameters was evaluated so that the sensitivity to growth assumptions were included in the uinvestigation. Overall the a4a model based on the length slicing is considered suitable for advice. The SS3 model is thought to be inappropriate due to the known issues with aging.

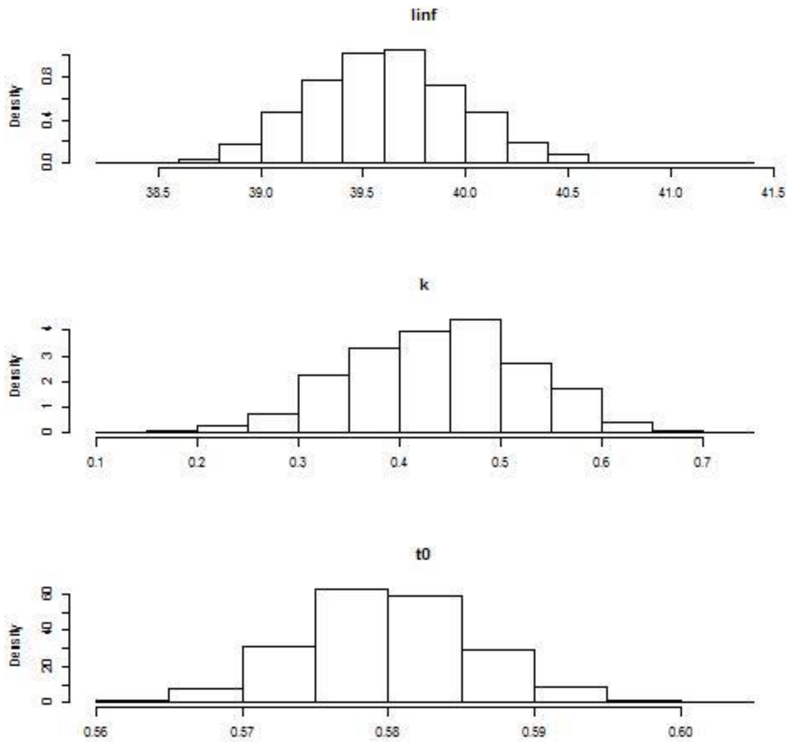


Figure 6.6.3.2.8 Sole in GSA 17. Growth parameters distributions used to account for uncertainty in the slicing procedure.

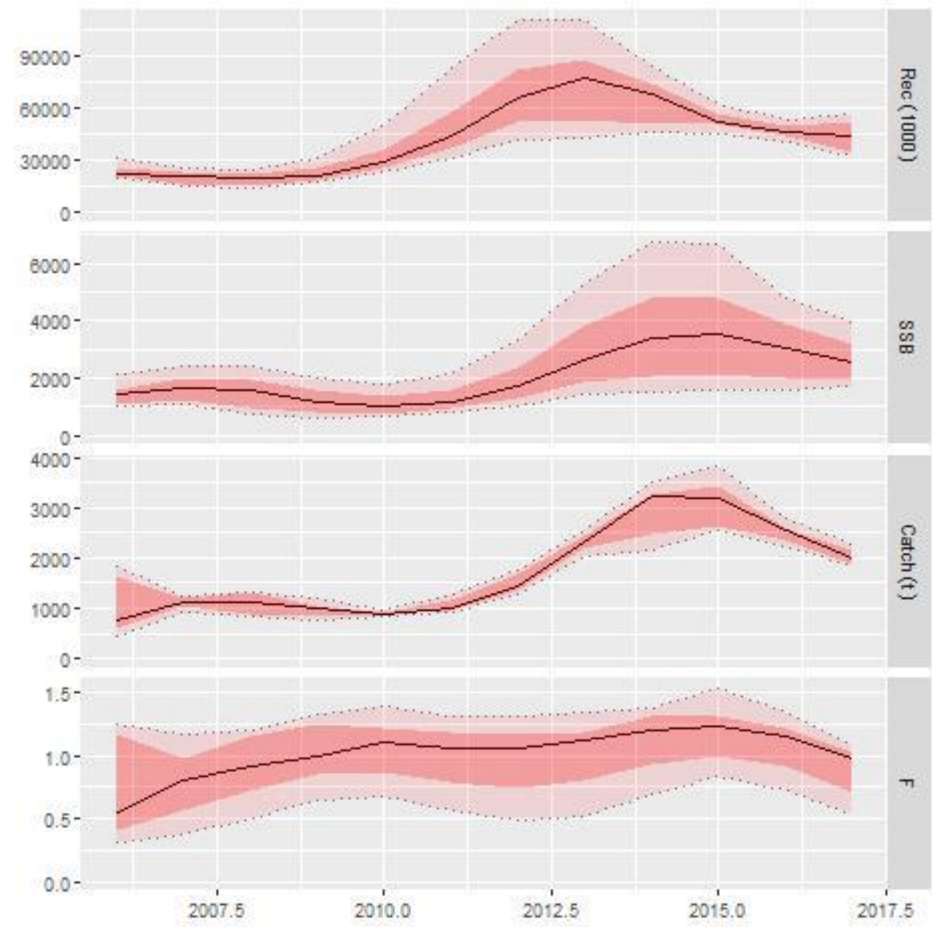


Figure 6.6.3.2.9 Sole in GSA 17. Results of the a4a run with 1000 iterations obtained from the distribution of growth parameters.

6.6.4 Reference Points

Reference points and short term forecasts are reported for the SS3 model (Table 6.6.4.1).

The STECF EWG 18-02 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object created with the results of the SS3 assessment.

Current F (0.65, estimated as the $F_{bar1\text{-}4}$ in the last year of the time series, 2017) is higher than $F_{0.1}$ (0.24), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that Sole stock in GSA 17 is being overfished.

The reference points were estimated using the FLBRP package, applying the Yield per Recruits approach, where F0.1 is considered a proxy of FMSY.

Table 6.6.4.1 Sole in GSA 17. Main reference points defined with the Yield per recruit analysis (SS3 model).

Refpt	harvest	yield	rec	ssb	biomass
F0.1	0.24	0.05	1.00	0.24	0.32

Reference points and short term forecasts are reported for the a4a model (Table 6.6.4.2) as the EWG 18-16 rejected the SS3 model run with the age matrices obtained from the otholith readings. The EWG 18-16 asked to report reference points when accunting for uncertainty around the growth parameters as well (Figure 6.6.4.1. and Table 6.6.4.3) in order to quantify the uncertainty surrounding the estimates obtained from the assessment run with the new slicing.

The STECF EWG 18-02 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object created with the results of the SS3 assessment.
Current F (0.72, estimated as the F_{bar1-3} in the last year of the time series, 2017) is higher than $F_{0.1}$ (0.10), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that Sole stock in GSA 17 is over-exploited.

The reference points were estimated using the FLBRP package, applying the Yield per Recruits approach, where F0.1 is considered a proxy of FMSY.

Table 6.6.4.2 Sole in GSA 17. Main reference points defined with the Yield per recruit analysis (a4a model).

refpt	harvest	yield	rec	ssb	biomass
F0.1	0.10	0.09	1.00	0.50	0.51

Table 6.6.4.3 Sole in GSA 17. Main reference points defined with the Yield per recruit analysis (a4a model accounting for uncertainty around growth parameters).

refpt	harvest	yield	rec	ssb	biomass
F0.1	0.16 (0.03)	0.04 (0.015)	1.00 (0.0)	0.20 (0.03)	0.27 (0.04)

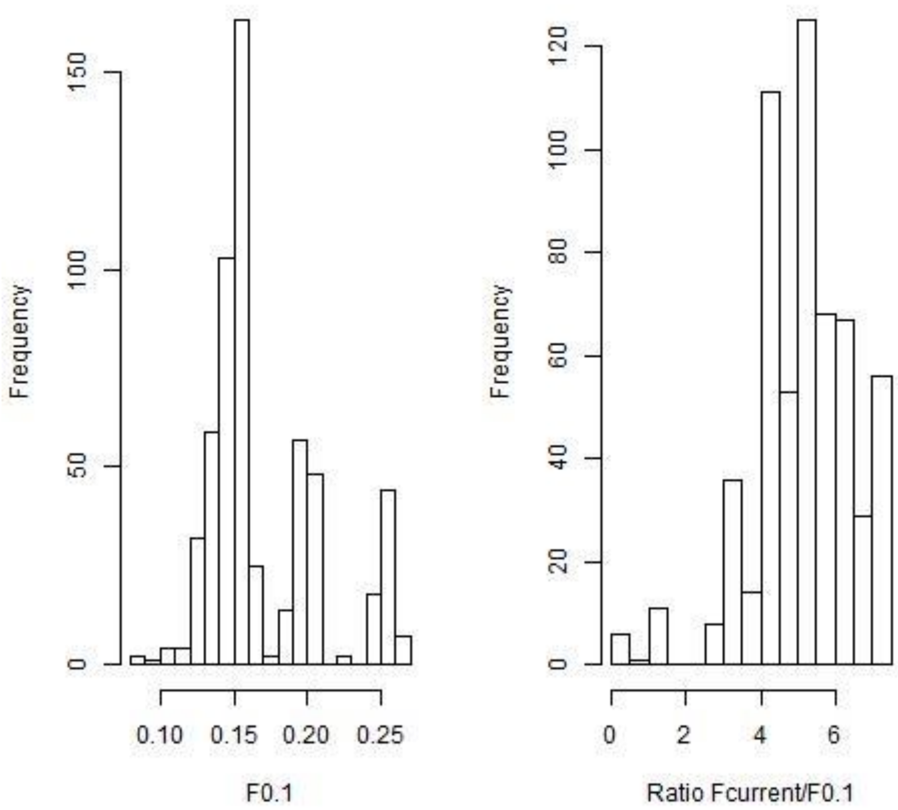


Figure 6.6.4.1 Sole in GSA 17. Distribution of F0.1 and the ratio of Fcurrent over F0.1 when accounting for uncertainty around growth parameters.

6.6.5 SHORT TERM FORECAST AND CATCH OPTIONS

Short term forecast was carried out for the SS3 model using the routine made available by the JRC.

The reference point used was F0.1=0.24. The recruitment from 2017 to 2019 was assumed equal to the geometric mean of the last 7 years (from 2011 onwards). 22 different F scenarios were simulated in order to evaluate the change in SSB and in the catch in the short term (Table 6.6.5.1 and Figure 6.6.5.1).

Table 6.6.5.1 Sole in GSA 17. Short term forecast for the SS3 model; catch(2017)=1953 tons, catch(2018)=1519 tons.

Rationale	Ffactor	Fbar	Catch2017	Catch2018	Catch2019	Catch2020	SSB2019	SSB2020	SSB_change 2018-2020(%)	Catch_change 2017-2019(%)
Zero catch	0	0	1953	1519	0	0	2257	3778	67.4	-100.0
High long term yield (F0.1)	0.37	0.24	1953	1519	659	855	2257	3023	34.0	-66.3
Status quo	1	0.65	1953	1519	1497	1491	2257	2095	-7.2	-23.4
F upper	0.51	0.33	1953	1519	873	1065	2257	2782	23.3	-55.3
F lower	0.25	0.16	1953	1519	460	630	2257	3249	44.0	-76.4
Different scenarios	0.1	0.06	1953	1519	196	287	2257	3552	57.4	-90.0
	0.2	0.13	1953	1519	379	530	2257	3342	48.1	-80.6
	0.3	0.19	1953	1519	551	736	2257	3146	39.4	-71.8
	0.4	0.26	1953	1519	713	911	2257	2963	31.3	-63.5
	0.5	0.32	1953	1519	864	1057	2257	2792	23.7	-55.7
	0.6	0.39	1953	1519	1007	1180	2257	2633	16.7	-48.4
	0.7	0.45	1953	1519	1141	1282	2257	2484	10.1	-41.6
	0.8	0.52	1953	1519	1266	1366	2257	2346	3.9	-35.1
	0.9	0.58	1953	1519	1385	1435	2257	2216	-1.8	-29.1
	1.1	0.71	1953	1519	1602	1535	2257	1981	-12.2	-18.0
	1.2	0.78	1953	1519	1701	1570	2257	1875	-16.9	-12.9
	1.3	0.84	1953	1519	1794	1597	2257	1776	-21.3	-8.1
	1.4	0.91	1953	1519	1883	1616	2257	1683	-25.4	-3.6
	1.5	0.97	1953	1519	1966	1629	2257	1596	-29.3	0.7
	1.6	1.04	1953	1519	2045	1638	2257	1514	-32.9	4.7
	1.7	1.10	1953	1519	2119	1641	2257	1438	-36.3	8.5
	1.8	1.17	1953	1519	2190	1642	2257	1366	-39.5	12.1
	1.9	1.23	1953	1519	2256	1639	2257	1299	-42.4	15.5
	2	1.30	1953	1519	2319	1633	2257	1235	-45.3	18.8

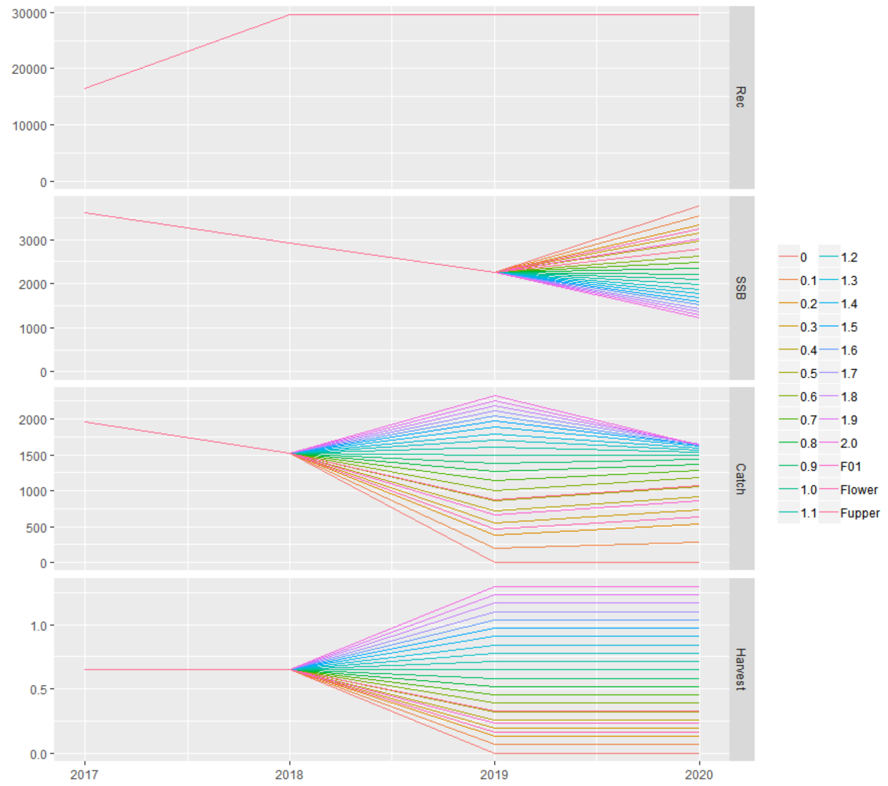


Figure 6.6.5.1 Sole in GSA 17. Short term forecast for the SS3 run.

The SS3 analysis showed that fishing at F=0.24 would increase the SSB (from 2018 to 2020) of about the 34%, and decrease the catch (from 2017 to 2019) of about the 66%, while fishing at the status quo level would decrease the SSB of 7% and the catch of the 23%.

Short term forecast was carried out for the a4a model using the routine made available by the JRC.

The reference point used was F0.1=0.15. The recruitment from 2017 to 2019 was assumed equal to the geometric mean of the last 7 years (from 2011 onwards). 22 different F scenarios were simulated in order to evaluate the change in SSB and in the catch in the short term (Table 6.6.5.2 and Figure 6.6.5.2).

Table 6.6.5.2 Sole in GSA 17. Short term forecast for the a4a model; catch(2017)=1856 tons, catch(2018)=1942 tons.

Rationale	Ffactor	Fbar	Catch2017	Catch2018	Catch2019	Catch2020	SSB2019	SSB2020	SSB_change 2018-2020(%)	Catch_change 2017-2019(%)
Zero catch	0.00	0.00	1883.67	1915.23	0.00	0.00	4375.31	7624.30	94.34	-100.00
High long term yield (F0.1)	0.14	0.10	1883.67	1915.23	461.69	924.87	4375.31	6981.23	77.95	-75.49
Status quo	1.00	0.72	1883.67	1915.23	2157.06	2338.72	4375.31	4642.85	18.34	14.51
Different scenarios	0.10	0.07	1883.67	1915.23	339.56	706.13	4375.31	7151.23	82.28	-81.97
	0.20	0.14	1883.67	1915.23	641.66	1214.72	4375.31	6730.90	71.57	-65.94
	0.30	0.22	1883.67	1915.23	911.00	1579.21	4375.31	6356.80	62.03	-51.64
	0.40	0.29	1883.67	1915.23	1151.59	1838.46	4375.31	6023.31	53.53	-38.86
	0.50	0.36	1883.67	1915.23	1366.92	2020.76	4375.31	5725.56	45.94	-27.43
	0.60	0.43	1883.67	1915.23	1559.99	2146.84	4375.31	5459.33	39.16	-17.18
	0.70	0.51	1883.67	1915.23	1733.42	2231.89	4375.31	5220.94	33.08	-7.98
	0.80	0.58	1883.67	1915.23	1889.47	2287.09	4375.31	5007.20	27.63	0.31
	0.90	0.65	1883.67	1915.23	2030.11	2320.67	4375.31	4815.32	22.74	7.77
	1.10	0.80	1883.67	1915.23	2271.84	2345.71	4375.31	4487.66	14.39	20.61
	1.20	0.87	1883.67	1915.23	2375.77	2344.98	4375.31	4347.87	10.83	26.12
	1.30	0.94	1883.67	1915.23	2470.00	2338.95	4375.31	4221.81	7.61	31.13
	1.40	1.01	1883.67	1915.23	2555.55	2329.44	4375.31	4108.03	4.71	35.67
	1.50	1.09	1883.67	1915.23	2633.34	2317.75	4375.31	4005.24	2.09	39.80
	1.60	1.16	1883.67	1915.23	2704.15	2304.84	4375.31	3912.29	-0.28	43.56
	1.70	1.23	1883.67	1915.23	2768.70	2291.42	4375.31	3828.18	-2.42	46.98
	1.80	1.30	1883.67	1915.23	2827.60	2277.96	4375.31	3752.00	-4.36	50.11
	1.90	1.38	1883.67	1915.23	2881.42	2264.80	4375.31	3682.96	-6.12	52.97
	2.00	1.45	1883.67	1915.23	2930.65	2252.19	4375.31	3620.34	-7.72	55.58

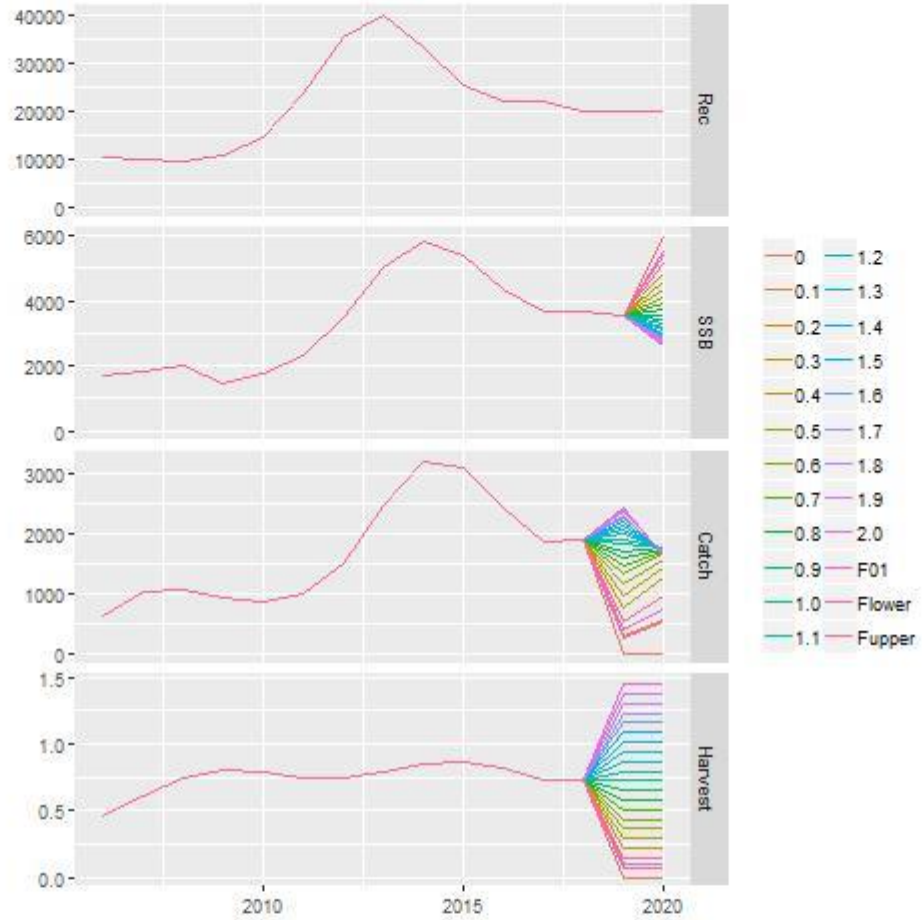


Figure 6.6.5.2 Sole in GSA 17. Short term forecast for the a4a run.

The a4a analysis showed that fishing at F=0.10 would increase the SSB (from 2018 to 2020) of about the 78%, and decrease the catch (from 2017 to 2019) of about the 75%, while fishing at the status quo level would increase the SSB of only 18% and the catch of the 14%.

6.7 Spottail Mantis Shrimp in GSA 17-18

6.7.1 Stock Identity and Biology

BIOLOGY

The spot-tail mantis shrimp is found in the Mediterranean and in the adjacent eastern Atlantic ocean, from the Gulf of Cadiz to Angola. It is found from sublittoral depths on sandy and muddy bottoms to around 150 m depth (Abelló *et al*., 2002). There is not a clear distribution pattern by size and depth; however, juveniles are generally more abundant in waters shallower than 30 m depth (Abelló and Martín, 1993). In the Italian waters, it is found along the coasts of the whole peninsula, and is particularly abundant in the northern and central Adriatic Sea, where it ranks amongst the most relevant species exploited by commercial fisheries (Froglia, 2010).

The spot-tail mantis shrimp digs U-shaped burrows in which it hides during the day. It has threfore a preference for areas with suitable burrowing substrate, such as fine sand and sandy-muddy bottoms, especially where the influence of river sediment intakes is important (Froglia, 1996; Atkinson *et al*., 1997). In fact, it is very abundant on the continental shelves at the mouths of Ebro, Rhone, Po, and Nile rivers, as a matter of fact the species is very abundant in the western side of the Adriatic basin, while it is almost absent in the eastern side, where the sediment features are not as suitable for their borrowing behaviour. It is a strongly sedentary species and seasonal trends appearing in catch data are due more to its reproductive and burrowing behaviour, and recruitment pattern, than to temporal changes in its distribution (Maynou *et al*., 2004).
In the present assessment the combined data coming from the two Adriatic GSAs (17 and 18) have been used.

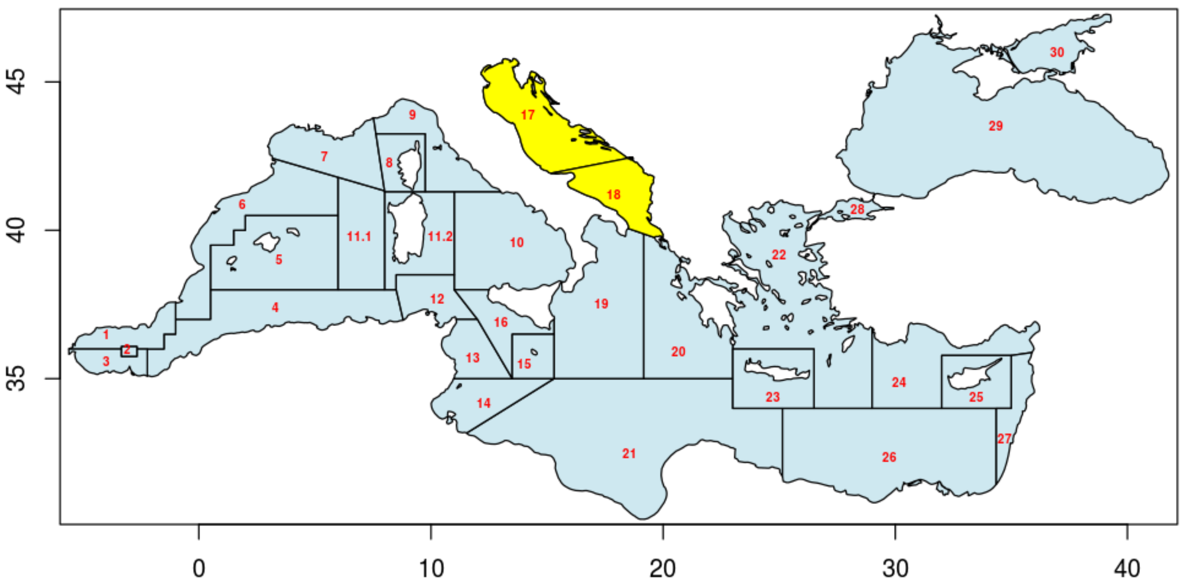


Figure 6.7.1.1 Geographical location of GSAs 17 and 18

GROWTH

Froglia *et al*. (1996) used an indirect method to study the growth of Spot-tail mantis shrimp in GSA 17. The length frequency distributions for males and females recorded during experimental trawls carried out in the central area of the GSA 17 in 1994 and 1995 (Froglia *et al*., 1996) showed similar size ranges for both sexes. The largest specimens were collected in September 1994 (39 mm CL for males and females) and the smallest specimens were observed in November 1994 (5 mm CL for males and females). The last probably represent the new generation of Spot-tail mantis shrimps whose larvae settled on the bottom in late summer and early autumn of the same year. The results of the study indicated that the growth rate is similar for males and females, both sexes reaching around 18 mm CL at the end of the first year of life and around 32 mm CL at the end of the third year of life. It seems that mantis shrimp individuals live up to five or six years of age.
The Von Bertalannfy (VBGF) parameters were computed using the above data and are presented in Table 6.7.1.1. The length weight relationship parameters were derived from the STECF 17 – 15 EWG and are inline with the growth parameters also used in the assessment of Spottail mantis shrimp in that EWG.

Table 6.7.1.1 Spottail mantis shrimp in GSAs 17 and 18. Von Bertalanffy growth parameters and length weight relationship parameters.

L_{inf}	k	t_0	a	b
41.53	0.49	-0.0105	0.00133	3.045

Maturity
The life cycle of this species is well known: the spawning period is concentrated from winter to spring and planktonic larvae are found in summer, with the settlement of post-larvae occurring from the end of summer to mid-autumn. Recruitment to the fishery starts in late autumn, with full recruitment being reached between January and May (Maynou et al., 2004). In the central Adriatic (GSA 17), the peak of ovarian maturity was reported in February and March, when up to 80% of the females had ripe ovaries (Froglia, 1996). Spent females were mainly observed from April to September, when the sex ratio (M/F) is strongly in favour of males (Piccinetti and Piccinetti Manfrin, 1971; Froglia *et al*., 1996). According to Abelló and Martín (1993) and Froglia (1996), settlement of post-larvae takes place at the end of summer and the beginning of autumn at 17-20 mm Total Length (TL), or 3-4 mm Carapace Length (CL). In GSA 18 the monthly percentage of female maturity stages shows that the reproductive period extends from October to June with a peak during the coldest months (winter-early spring). L50 (±s.e.) for GSA 18 is 21.1 mm (Carbonara et al., 2013).
Combined maturity at age factors were calculated as a weighted average using the stock numbers. The vector of maturity at age is presented in Table 6.7.1.2.

Table 6.7.1.2 Spottail mantis shrimp in GSAs 17 and 18. Maturity by age.

age	0	1	2	3	4	5	6+
maturity	0.003	0.809	1	1	1	1	1

Natural Mortality

The vector of natural mortality as obtained from PRODBIOM model (Abella *et al*., 1998) using the growth parameters in Table 6.7.1.1 and is shown in Table 6.7.1.3.

Table 6.7.1.3 Spottail mantis shrimp in GSAs 17 and 18. Mortality by age.

age	0	1	2	3	4	5	6+
mortality	1.2	0.7	0.6	0.52	0.48	0.48	0.48

Fishery

Catches show marked dial periodicity with significantly more animals caught at night (Froglia and Giannini, 1989; Froglia and Gramitto, 1989). The burrowing behaviour of *S. mantis* makes it vulnerable only when individuals are out of their burrows and this occurs mainly at night, between sunset and sunrise. Seasonal variations in catchability result from reduced out-of-burrow activity, because females rarely exit their burrow when they are incubating their egg mass in spring and early summer. Conversely, catches increases in winter, when mating takes place. Catches increase further in late autumn with the arrival of new recruits. The reproductive behaviour of the species also influences the relative proportion of males and females in the catches by season: females outnumber males only in winter (mating season), while the sex-ratio is biased towards males in spring and summer. Additionally, weather and sea conditions represent an important influence on the catchability of this species as catches increase after prolonged bad weather conditions probably because of disturbance of the burrow systems as a result of the high turbidity (Froglia *et al*., 1996).

Although *S. mantis* ranks first among the crustaceans landed in the Adriatic ports of GSA 17, it is not the target of a specialized fishery, but it is an important component of local multispecies trawl and gillnet fisheries. It is caught by 4 fisheries, namely DEMF, DEMSP, MDPSP and SPF within which 10 different fishing gears are being used. The main species caught in GSA 17 associated with mantis shrimp are *Sepia officinalis, Trigla lucerna, Merluccius merluccius, Mullus barbatus* and *Eledone* spp*.* As concerns artisanal fisheries, *S. mantis* is a by catch (only in few cases it also targeted) of gillnetters targeting *Solea solea*, especially during spring-summer seasons in the coastal area. Only in the Gulf of Trieste it is the target of a directed fishery; a small artisanal fishery with creels (Froglia and Giannini, 1989).

The species is absent from the landings reported from Croatia in the DCF database. Landings from Croatia where provided to the present EWG by experts attending the meeting for the years 2012 – 2017.

Like in GSA 17, mantis shrimp in GSA 18 is mainly a by-catch of trawlers and to a much lesser extent by small scale fisheries using gillnets and trammel nets. Fishing grounds are located along the coasts of the whole GSA 18. The species is landed with other important commercial species such as *Mullus spp., Pagellus sp., Eledone moschata, Octopus vulgaris., M. merluccius*, etc. The exploitation of mantis shrimp is mainly by the bottom trawlers, both on the western and the eastern sides. The main bulk of the catches both in GSA 17 and GSA 18 comes from the Italian fleet.

6.7.2 DATA

6.7.2.1 CATCH (LANDINGS AND DISCARDS)

In GSA 17 landings data for Italy where available since 2007, for Slovenia since 2005 and for Croatia data were not available in the DCF database but where provided in the EWG by experts from Croatia. In GSA 18 Italian landings where available since 2006.

In Table landings data are presented by country and GSA.

Table 6.7.2.1.1 Spottail mantis shrimp in GSAs 17 and 18. Landings data in tonnes by country.

	GSA 17				GSA 18	
	HRV	**ITA**	**SVN**	**Total**	**ITA**	**Total**
2005			4.6	4.6		
2006			2.4	2.4	1271.7	1271.7
2007		3905.1	7.2	3912.3	1258.5	1258.5
2008		3998.6	6.2	4004.8	916.8	916.8
2009		4529.3	3.6	4533.0	892.4	892.4
2010		4564.7	5.0	4569.7	454.1	454.1
2011		3786.2	3.6	3789.8	352.3	352.3
2012	2.2	3104.9	0.7	3107.8	631.7	631.7
2013	2.4	2127.6	0.3	2130.2	2195.9	2195.9
2014	4.5	2805.6	0.5	2810.5	1003.9	1003.9
2015	7.4	3063.3	0.8	3071.5	1010.8	1010.8
2016	11.3	3143.4	1.8	3156.4	929.2	929.2
2017	12.7	3076.0	1.2	3089.8	600.1	600.1

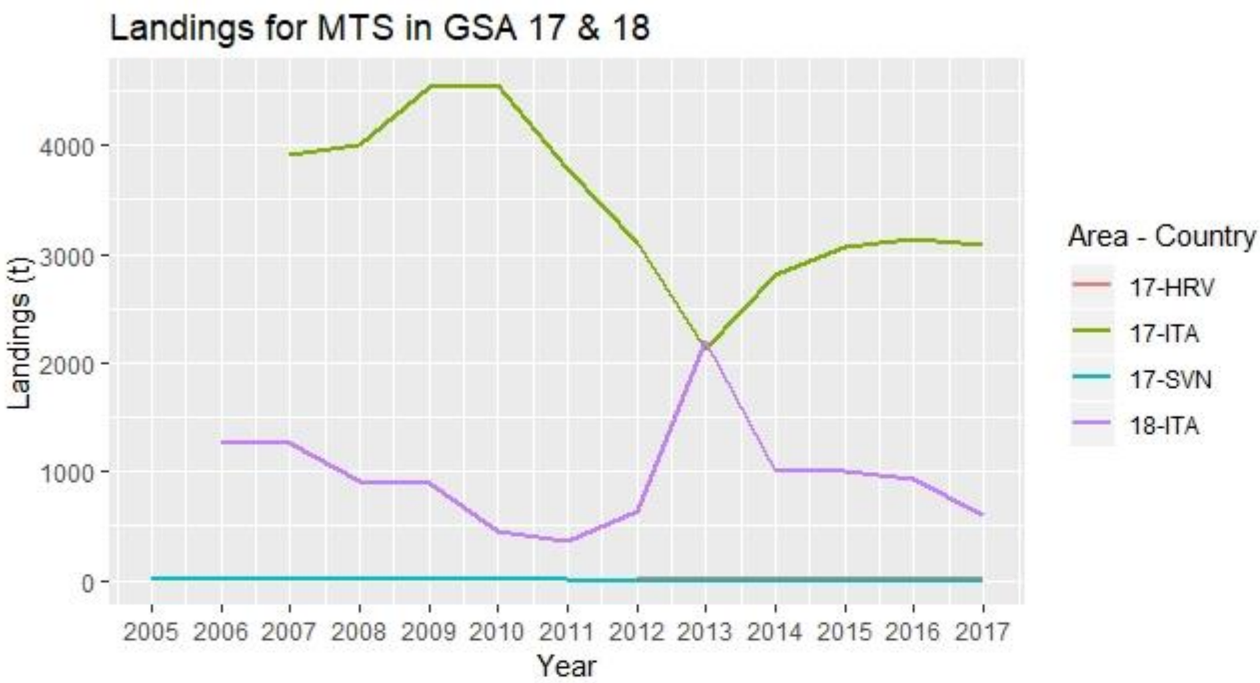


Figure 6.7.2.1.1. Spottail mantis shrimp in GSAs 17 and 18. Landings trend in tonnes by GSA and country from 2005 to 2017.

In the following figure (Figure 6.7.2.1.2) total landings are presented for both GSA 17-18. Missing landings from Italy for the beginning of the time series are responsible for the very low landings in the early years. After 2007 there is a slight increase in the trend followed by a slow decline until 2012. After 2012 landings are fluctuating around 4000 tonnes. It is clear that the trend in the landings data is governed by the landings of the Italian fleet.

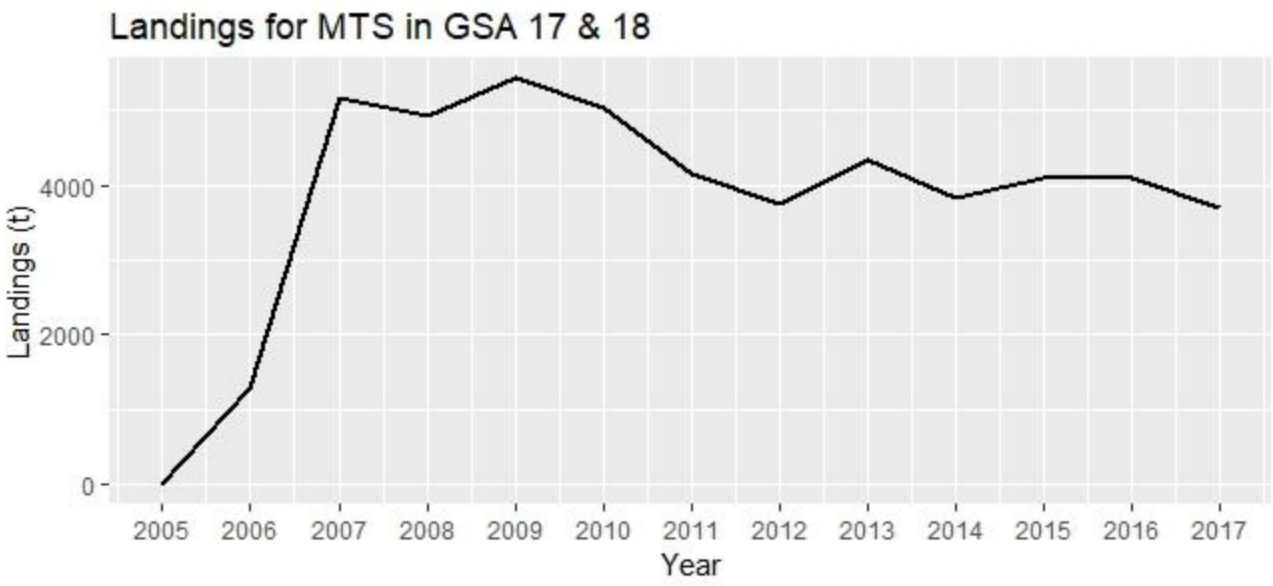


Figure 6.7.2.1.2 Spottail mantis shrimp in GSAs 17 and 18. Total landings in tonnes for both GSA's 17 and 18.

The following Tables present the landings of Spottail mantis shrimp in tonnes for GSA's 17 and 18 by country and gear.

Table 6.7.2.1.2 Spottail mantis shrimp in GSAs 17 and 18. Landings in tonnes by country and gear.

	GSA 17							
	ITA				SVN			
	GNS	GTR	OTB	TBB	FPO	GNS	GTR	OTB
2005					0.7	0.2	0.5	3.2
2006					0.4	0.2	0.3	1.5
2007	936.1		2969.0		0.3	0.4	0.5	6.1
2008	831.1		2858.6	308.8	0.4	0.9	1.2	3.7
2009	872.5		3167.3	489.5	0.3	0.5	0.6	2.2
2010	961.1		3163.4	440.3	0.4	0.3	1.0	3.2
2011	1136.3		2399.1	250.8	0.8	0.2	0.4	2.2
2012	1140.6		1681.1	283.2	0.1	0.1	0.2	0.4
2013	205.4		1681.9	240.4	0.0	0.0	0.1	0.1
2014	296.2		2325.7	183.7	0.0	0.0	0.1	0.3
2015	324.9		2476.8	261.6	0.0	0.0	0.1	0.6
2016	408.3	9.2	2531.3	194.6	0.0	0.0	0.1	1.7
2017	318.0	124.0	2458.0	176.0	0.1	0.1	0.4	0.6

Table 6.7.2.1.3 Spottail mantis shrimp in GSAs 17 and 18. Landings in tonnes by country and gear.

	GSA 18					
	ITA					
	GNS	GTR	LLS	OTHER	OTB	Total
2005						
2006	160.9	25.8	8.2	0.8	1076.0	1271.7
2007	87.9	12.6			1157.9	1258.5
2008	51.9	31.0			833.9	916.8
2009	54.1	18.1			820.1	892.4
2010	19.1	19.2			415.8	454.1
2011	44.3	19.4			288.6	352.3
2012	16.9	19.9			594.8	631.7
2013	45.0				2151.0	2195.9
2014	0.5	4.3			999.2	1003.9
2015	5.8	11.6			993.4	1010.8
2016	16.2	36.1			876.8	929.2
2017	0.9	74.5		0.0	524.7	600.1

Length frequency distribution was available for the years 2007 – 2017 for both GSA's. The following graphs present the length structure of Spottail mantis shrimp for GSA 17and GSA 18 first by GSA, year and gear and then in total for both GSA's through years.

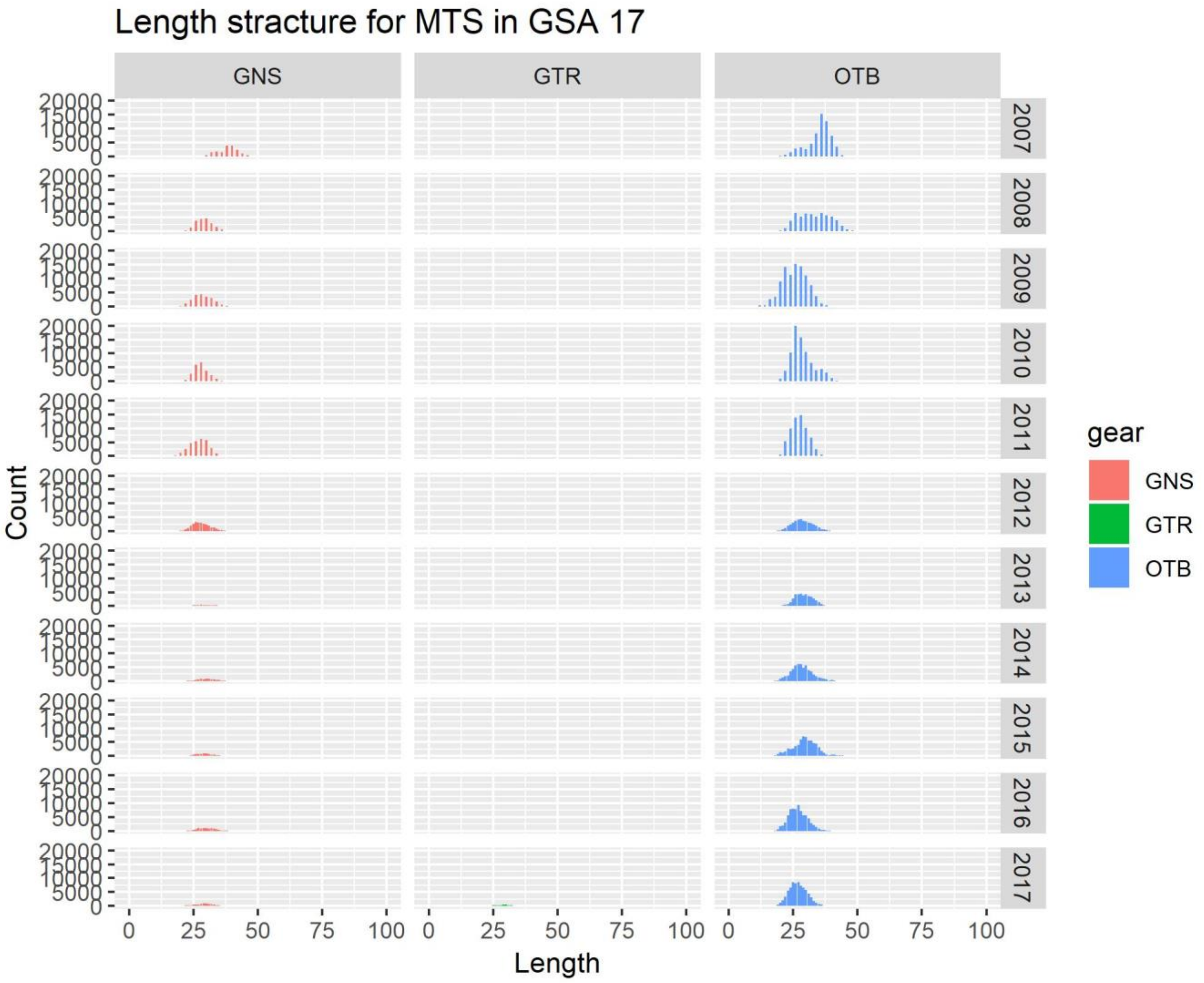


Figure 6.7.2.1.3 Spottail mantis shrimp in GSAs 17 and 18. Length structure for by year and gear.

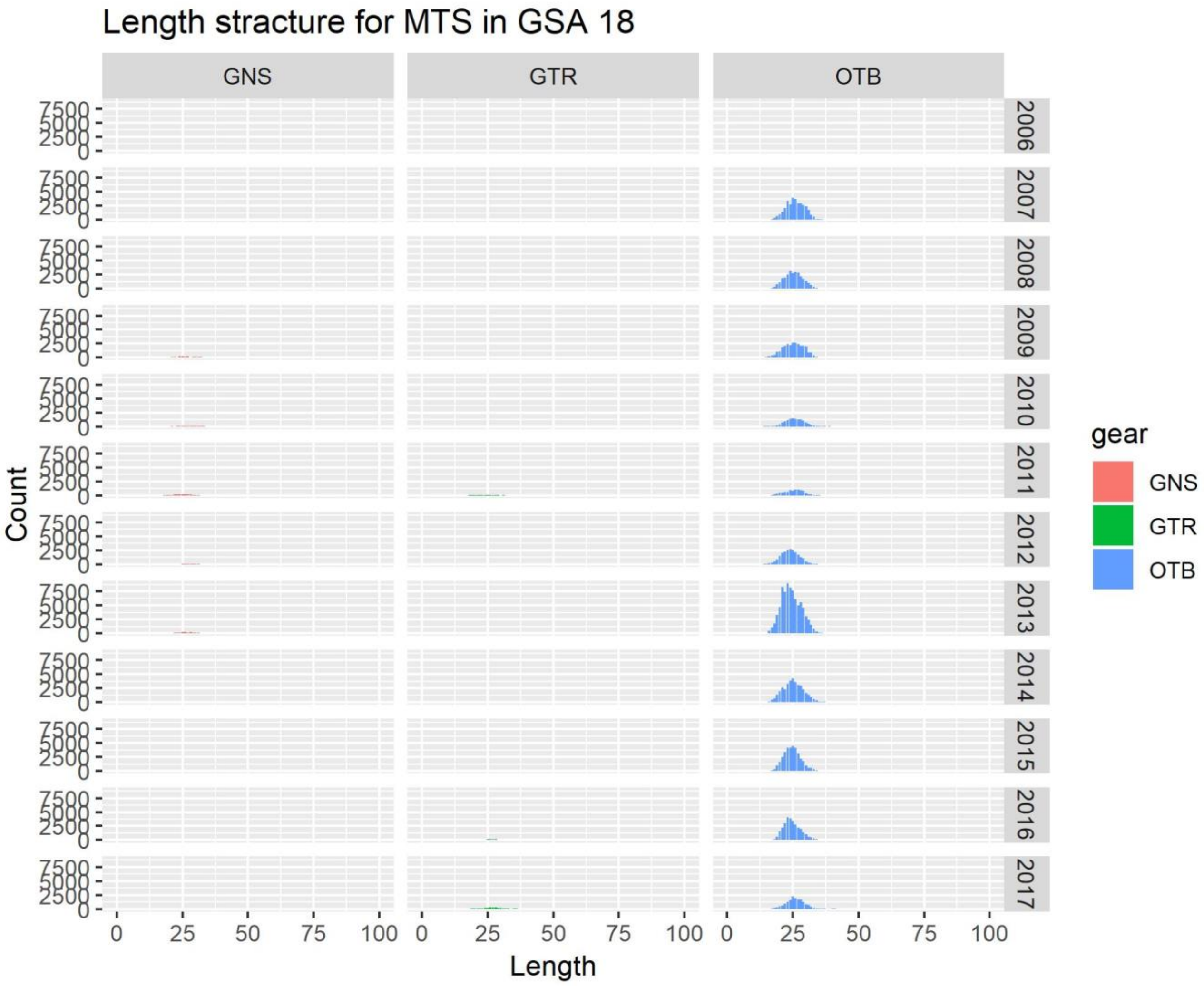


Figure 6.7.2.1.4 Spottail mantis shrimp in GSAs 17 and 18. Length structure by gear and year.

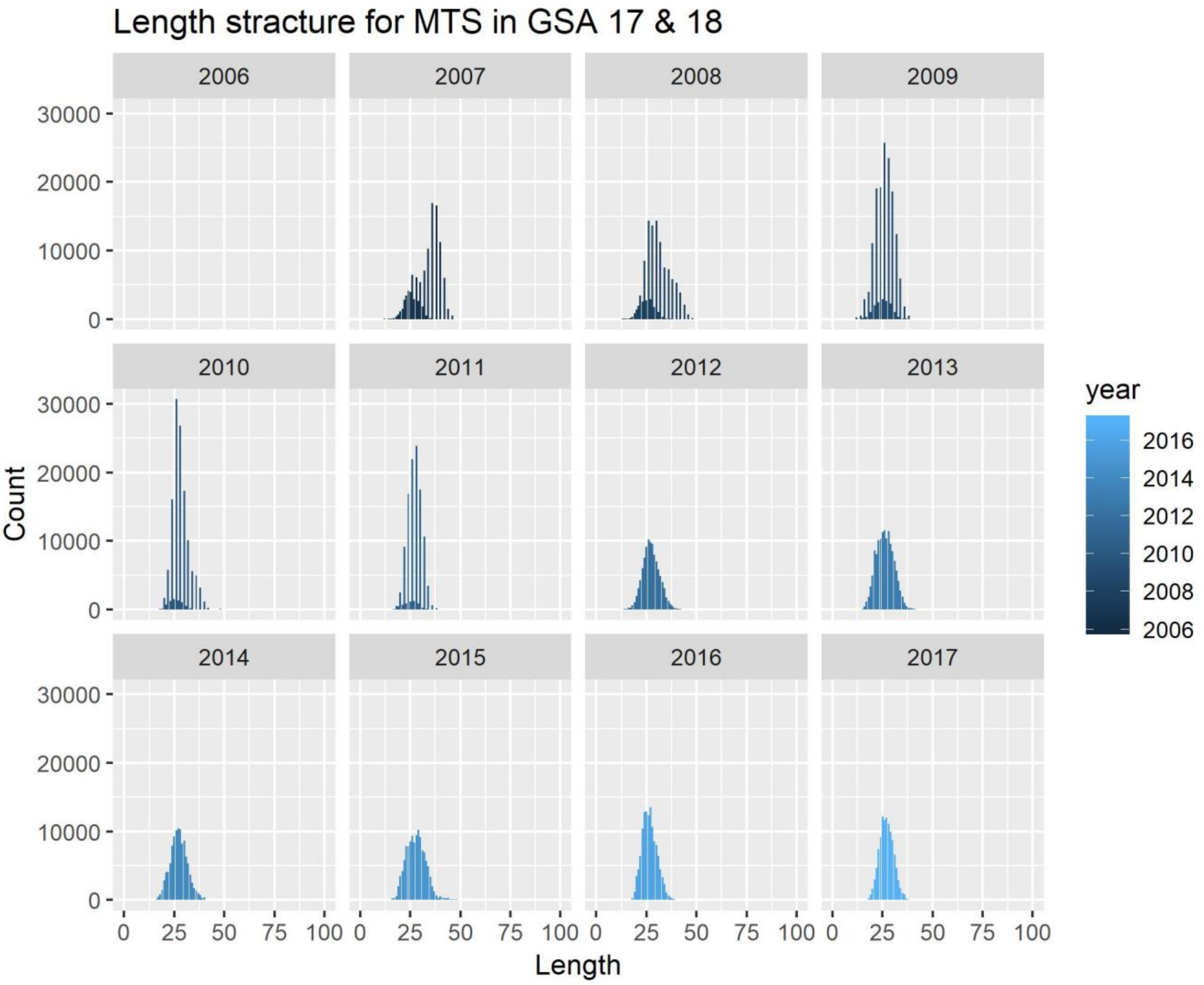


Figure 6.7.2.1.5 Spottail mantis shrimp in GSAs 17 and 18. Length structure by year for all gears.

DISCARDS

Discards data were available in the DCF database. With the main bulk of the discards coming from the Italian part. In the following table discards data in tonnes are presented.

Table 6.7.2.1.4 Spottail mantis shrimp in GSAs 17 and 18. Discards data in tonnes by country and year.

	GSA 17			GSA 18	
	ITA	SVN	Total	ITA	Total
2005		0.41	0.41		
2006		0.13	0.13		
2007		0.89	0.89		
2008		0.54	0.54		
2009		0.30	0.30	90.91	90.91
2010	374.53	0.44	374.97	93.17	93.17
2011	721.88	0.26	722.14	61.95	61.95
2012	103.06	0.02	103.08	269.30	269.30
2013	258.04	0.00	258.04	426.41	426.41
2014	398.68	0.01	398.69	78.71	78.71
2015	335.15	0.05	335.20	119.46	119.46
2016	1041.90	0.10	1042.00	144.42	144.42
2017	447.00	-5.91	441.09	25.41	25.41

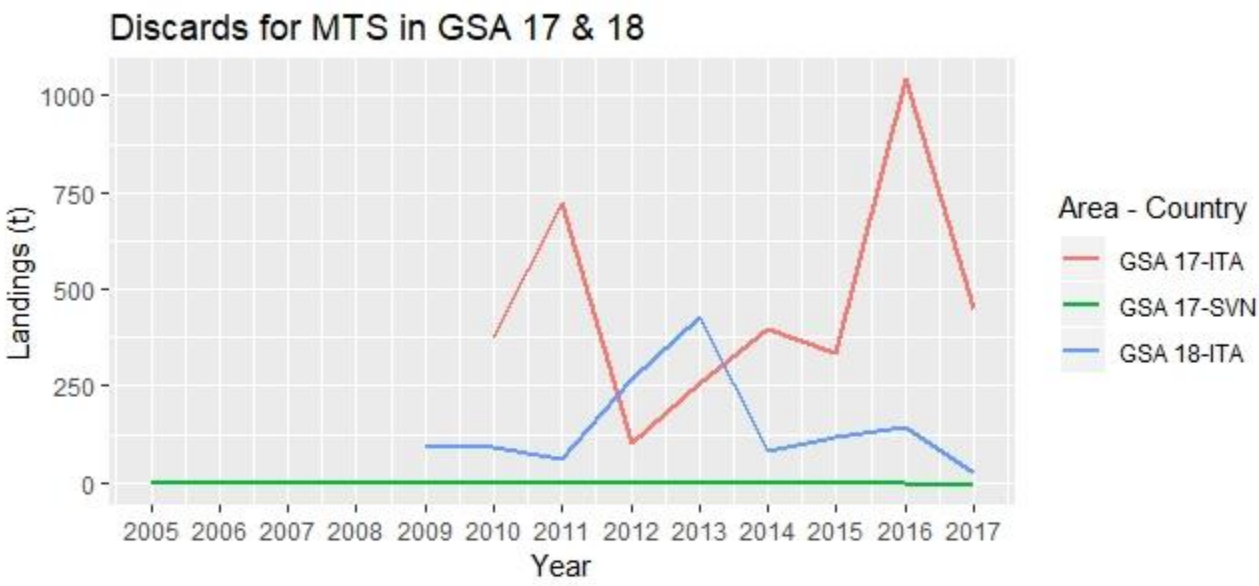


Figure 6.7.2.1.6 Spottail mantis shrimp in GSAs 17 and 18. Discards data in tonnes by country.

Table 6.7.2.1.5 Spottail mantis shrimp in GSAs 17 and 18. Discards in tonnes by country and gear.

	GSA 17						
	ITA			SVN			
	GNS	OTB	TBB	GNS	GTR	OTB	TOTAL
2005.00				0.00	0.00	0.41	0.41
2006.00				0.00	0.00	0.13	0.13
2007.00				0.01	0.00	0.88	0.89
2008.00				0.03	0.00	0.51	0.54
2009.00				0.01	0.00	0.29	0.30
2010.00		374.53		0.00	0.00	0.44	374.97
2011.00	0.95	704.83	16.10	0.00	0.00	0.26	722.14
2012.00		103.06		0.00	0.00	0.01	103.08
2013.00		258.04		0.00	0.00	0.00	258.04
2014.00		394.41	4.28	0.00	0.00	0.01	398.69
2015.00		324.21	10.94	0.00	0.00	0.05	335.20
2016.00		1041.90		0.00	0.00	0.10	1042.00
2017.00		403.00	44.00	0.00	0.01	0.08	441.09

Table 6.7.2.1.6 Spottail mantis shrimp in GSAs 17 and 18. Discards in tonnes by country and gear.

	GSA 18		
	ITA		
	GNS	OTB	TOTAL
2005			
2006			
2007			
2008			
2009		90.91	90.91
2010		93.17	93.17
2011	1.19	60.77	61.95
2012	0.64	268.67	269.30
2013	2.86	423.55	426.41
2014		78.71	78.71
2015		119.46	119.46
2016		144.42	144.42
2017		25.41	25.41

In the following graphs length frequency distribution of discards by GSA is being presented as most of the discards come from OTB the presentation of discards structure by gear would not be informative.

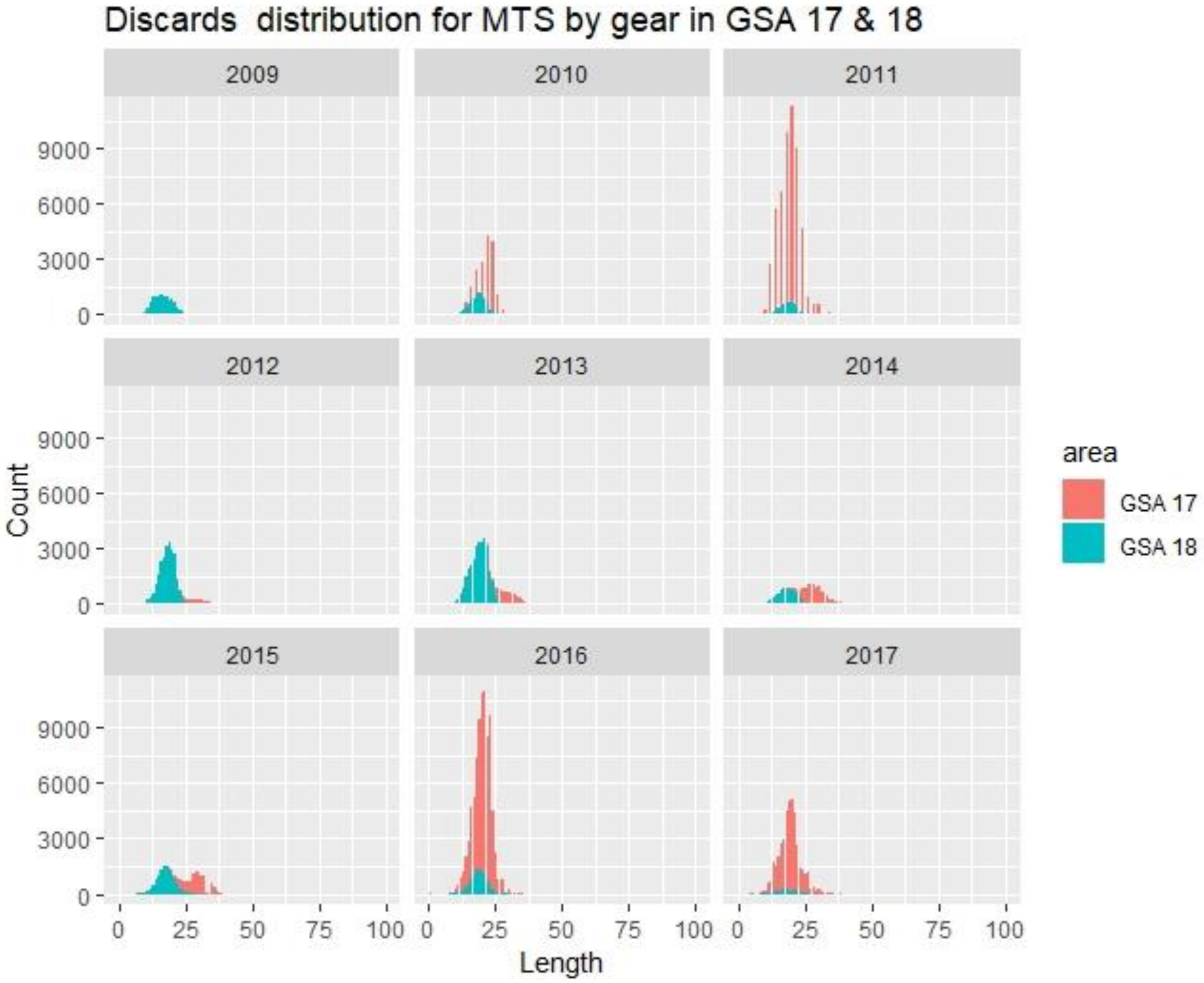


Figure 6.7.2.1.7 Spottail mantis shrimp in GSAs 17 and 18. Discards structure for GSA 17 and 18 for years 2009 to 2017

6.7.2.2 EFFORT

Effort data is dealt with in detail in Section 2.3, the main gears are the OTB and GNS.

6.7.2.3 SURVEY DATA

SoleMon survey

Fifteen rapido trawl fishing surveys were carried out in GSA 17 from 2005 to 2017: two systematic "pre - surveys" (spring and fall 2005) and twelve random surveys (spring and fall 2006, fall 2007-2016) stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). Hauls were carried out by day using 2- 4 rapido trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83).

Abundance and biomass indexes from rapido trawl surveys were computed using ATrIS software (Gramolini *et al.*, 2005) which also allowed drawing GIS maps of the spatial distribution of the stock, spawing females and juveniles. Underestimation of small specimens in catches due to gear selectivity was corrected using the selective parameters given by Ferretti and Froglia (1975).

The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to a number of different factors including the change in the number of hauls over time, and change of the survey time over the years. Precision may also be affected by the choice of parametric distribution, a normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-Poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al.* 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA.

Given that in the present EWG a stock object for the tunning index was provided from the STECF EWG 17 – 15 and no analytical data for the abundance by haul of the survey were available, no calculations were made for the previous years. Abundance by length was provided for the year 2017 and it was age sliced using the same growth parameters as the rest of the years.

The SoleMon trawl surveys provided trend in abundance for *S. mantis.* Figure 6.7.2.3.1. displays the stratified abundance indices by age obtained in GSA 17 from 2005 to 2017 during fall survey. The trends in biomass and abundance indices show a clear decrease of the stock in 2007 followed by an increase in the rest of the time series with a peak in 2015. Years 2016 and 2017 shows a decline in the end of the time series.

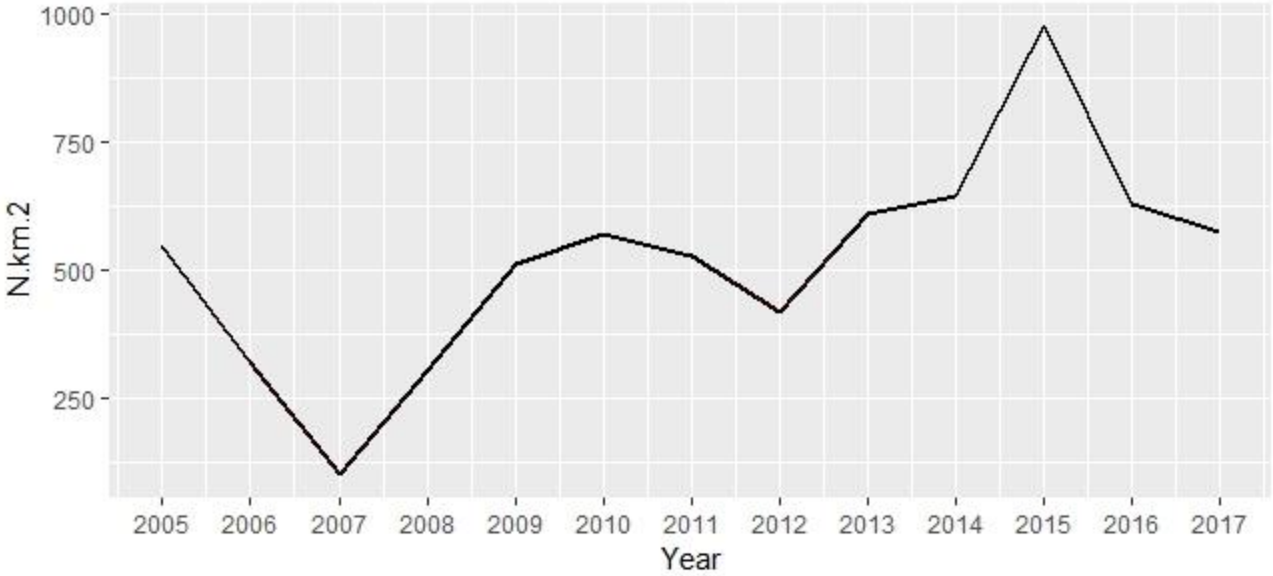


Figure 6.7.2.3.1 Spottail mantis shrimp in GSAs 17 and 18. Abundance by km2 for SOLEMON survey for the years 2005 – 2017.

Size and therefore age distribution was only available through years 2011 through 2017 and these were the years used in the analytical assessments. The following figure (Figure 6.7.2.3.2) displays the age structure by age for Spottail mantis shrimp.

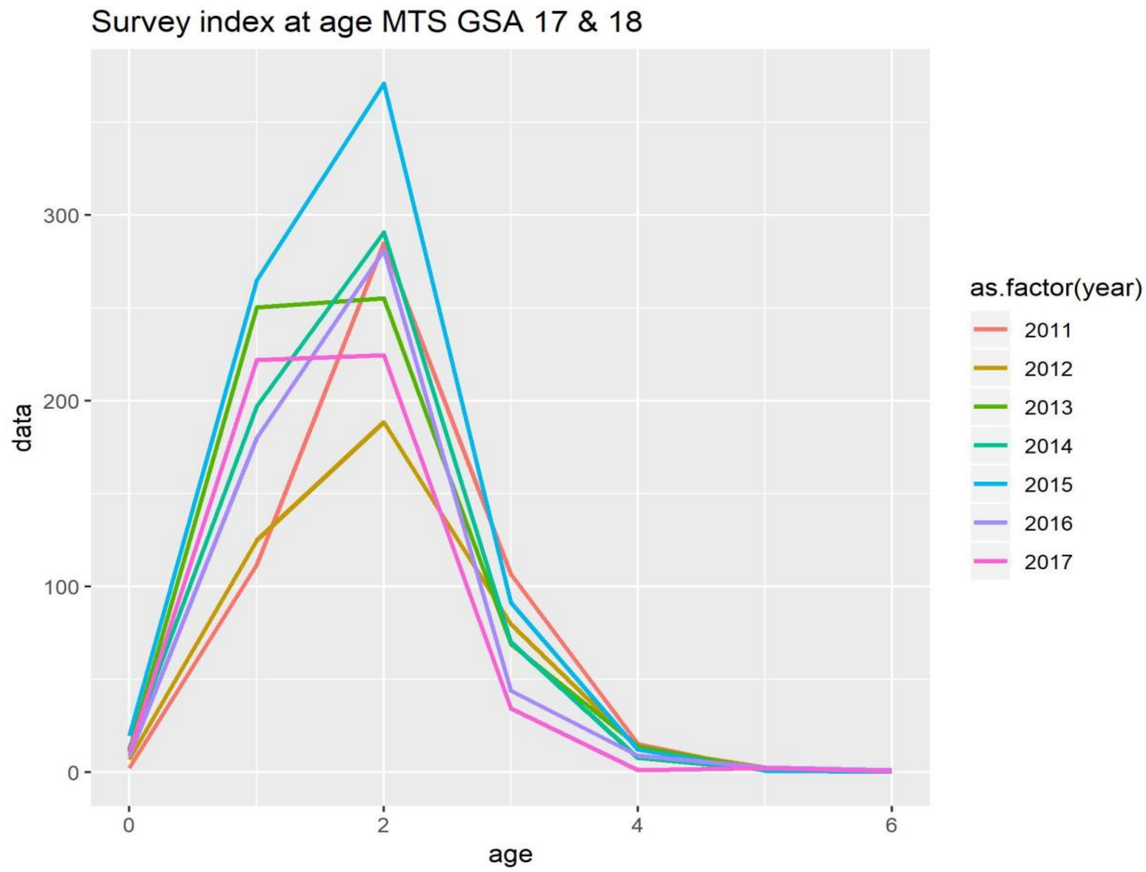


Figure 6.7.2.3.2 Spottail mantis shrimp in GSAs 17 and 18. Age structure of SOLEMON survey for ages 2011 – 2017.

MEDITS survey

MEDITS survey was carried out in GSAs 17 and 18 since 1994. Although the target of the survey are demersal species, Spot-tail mantis shrimp is scarcely caught. This is due to the behaviour of the species that spends most of the time borrowed during the daylight hours. In GSA 17 the number of specimens measured in 2009, 2010, 2011 and 2013 was really low mainly due to the paucity of individuals in the catches. However, based on the DCF data call, abundance and biomass indices were calculated for GSAs 17 and 18 using the ad hoc script.

MEDITS survey was deemed inappropriate to be used as tuning index of Spot-tail mantis shrimp in GSA17 and GSA 18.

6.7.3 STOCK ASSESSMENT

During EWG 18-16 the stock assessment was performed over the period 2008-2017. Discards were included in the analysis. Since no discard data were available for 2008-2009 in GSA 17 and for 2008 in GSA 18, an estimate based on the average discard ratios and discard age structures of the available nearest years was performed.

In the case of Spottail mantis catch data provided in the DCF database were used for the period 2008 - 2017. Landings and Discards in numbers at age were derived from deterministic age slicing the numbers at length provided from the DCF. Age slicing performed by using the l2a function of FLR and growth parameters reported in the section 6.7.1. The age classes considered from the catches range from 0 to 7; plus group was set at age 6. Data used are reported in Tables 6.7.3.1 and 6.7.3.2.

A natural mortality vector based on growth parameters (Section 6.7.1) computed using ProdBiom (Abella *et al.*, 1998) was used. The analyses were performed by sex combined, as growth is very similar between the two sexes. Given that the catches were composed mainly of individuals between 1 and 3 years, these ages were selected as the Fbar.

SoP correction was applied to catch numbers at age. Table 6.7.3.1 present the Sop correction vector applied. The empty years correspond to the absence of catch at age data for these years.
The SoleMon trawl survey was used as tuning index of the assessment and the age range used goes from 0 to 6. Age data from SoleMon were available for the period 2011-2017.

Two different assessment methods have been applied: Extended Survival Analysis (XSA) stock assessment model run through the FLXSA library implemented in R and a4a statistical catch at age framework developed by the Joint Research Centre (Jardim *et al*., 2015).

Table 6.7.3.1 Spottail mantis shrimp GSA 17 and 18. Vector of Sum of Products correction for the years 2008 - 2017.

year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

SoP	0.981	1.233	1.066	1.080	1.044	1.038	1.034	0.906	0.984	0.972

The following tables (Tables 6.7.3.2 – 6.7.3.3) present total catch and catch at age used in the stock assessment of Spottail mantis shrimp.

Table 6.7.3.2 Spottail mantis shrimp GSA 17 and 18. Total catch in tonnes 2008 – 2017.

year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
catch (t)	5423	5978	5501	4933	4112	5011	4292	4537	5272	4157

Table 6.7.3.3 Spottail mantis shrimp GSA 17 and 18. Catch numbers at age in thousands.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	3919	6374	1729	10031	4360	5567	1807	2477	7528	6614
1	26595	87324	48458	81735	56463	88563	46465	46871	123500	68180
2	47009	90859	84161	73208	54388	65196	62006	53915	61406	60727
3	18734	23014	16915	15528	15026	16673	15374	20398	11209	10133
4	7128	2268	5254	690	2089	1716	2798	3468	1035	1003
5	5727	552	3402	158	516	253	870	714	243	215
6+	11784	1	1628	18	607	452	848	2401	204	104

Table 6.7.3.4 Spottail mantis shrimp GSA 17 and 18. Catch mean weight at age in kg.

	2008	2009	2010	2011	2012
0	0.005	0.004	0.005	0.004	0.004
1	0.019	0.016	0.019	0.019	0.019
2	0.034	0.034	0.033	0.034	0.035
3	0.055	0.054	0.055	0.053	0.057
4	0.073	0.073	0.073	0.073	0.075
5	0.086	0.086	0.086	0.086	0.086
6	0.106	0.106	0.107	0.106	0.105
	2013	**2014**	**2015**	**2016**	**2017**
0	0.005	0.004	0.005	0.003	0.002
1	0.018	0.019	0.018	0.019	0.020
2	0.035	0.035	0.036	0.035	0.035
3	0.056	0.056	0.057	0.056	0.056
4	0.075	0.076	0.075	0.075	0.074
5	0.086	0.086	0.086	0.086	0.086
6	0.099	0.100	0.101	0.101	0.111

Table 6.7.3.5 Spottail mantis shrimp in GSA 17 and 18. Maturity, natural mortality, proportion of m and f before spawning.

age	0	1	2	3	4	5	6+
maturity	0.003	0.809	1	1	1	1	1
mortality	1.2	0.7	0.6	0.52	0.48	0.48	0.48
prop m	0	0	0	0	0	0	0
prop f	0	0	0	0	0	0	0

For the tuning index of the both assessment methods the STECF EWG decided to use the SOLEMON abundance index for the period 2011 – 2017. The following table presents the estimated numbers at age for the SOLEMON tuning index.

Table 6.7.3.6 Spottail mantis shrimp in GSA 17 and 18. SOLEMON numbers per km^2 at age.

	2011	2012	2013	2014	2015	2016	2017
0	2.274	6.885	11.93	12.792	19.565	8.809	10.837
1	111.818	124.793	250.346	197.101	264.861	180.132	221.84
2	284.956	188.431	255.198	290.757	370.62	280.719	224.506
3	106.759	79.726	69.14	69.965	91.178	43.987	34.294
4	15.284	13.225	14.067	7.937	12.04	8.971	1.242
5	1.176	2.609	1.534	1.347	0.993	2.725	2.461
6	0.484	1.191	0.654	0.612	0.412	1.266	0.631

The following figures (Figures) show the catch at age, index at age and weight at age for the input data of the assessments.

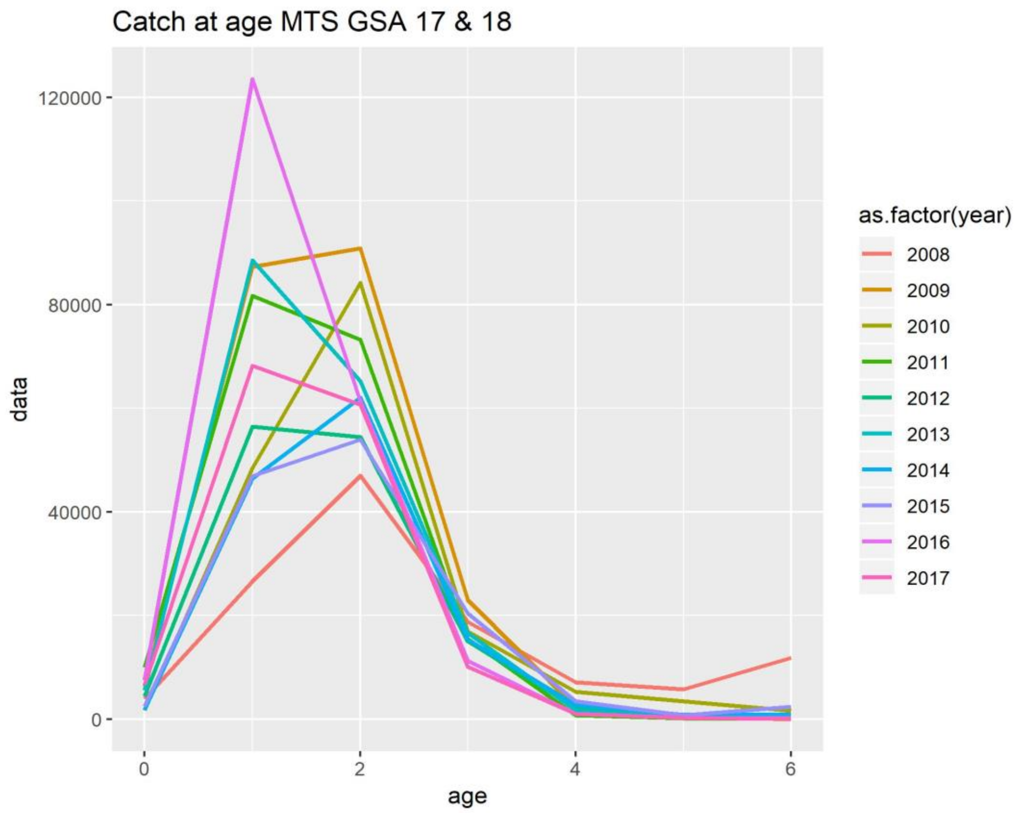


Figure 6.7.3.1 Spottail mantis shrimp in GSAs 17 and 18. Catch numbers in thousands at age.

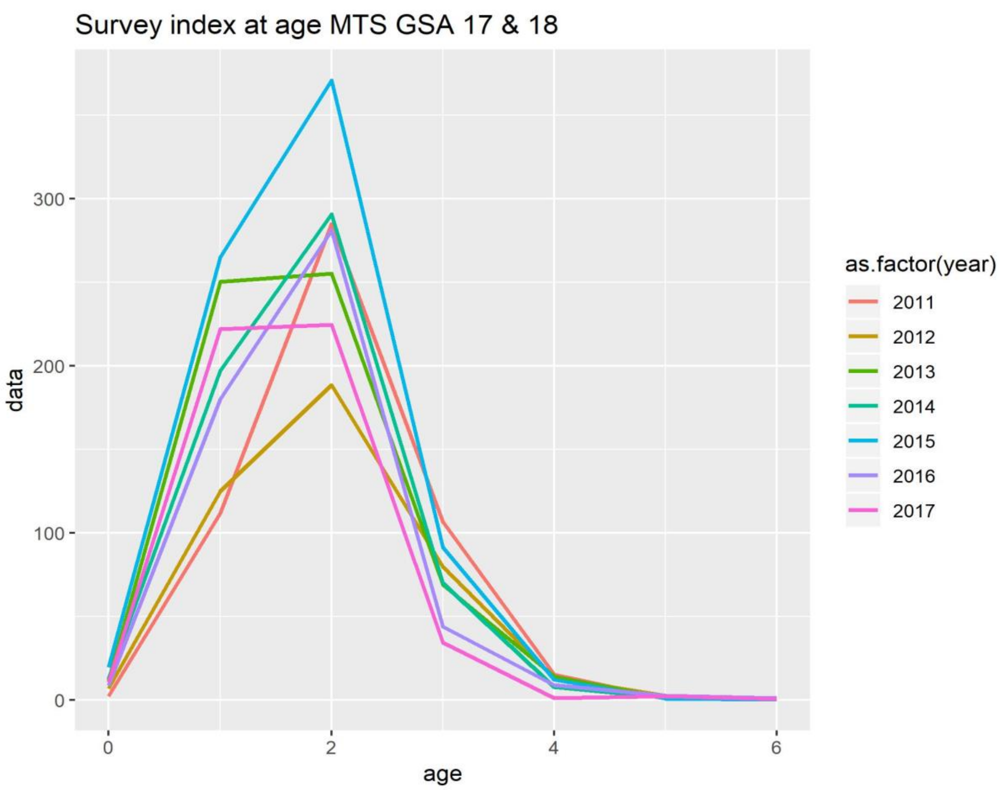


Figure 6.7.3.2 Spottail mantis shrimp in GSAs 17 and 18. SOLEMON tunning index numbers at age.

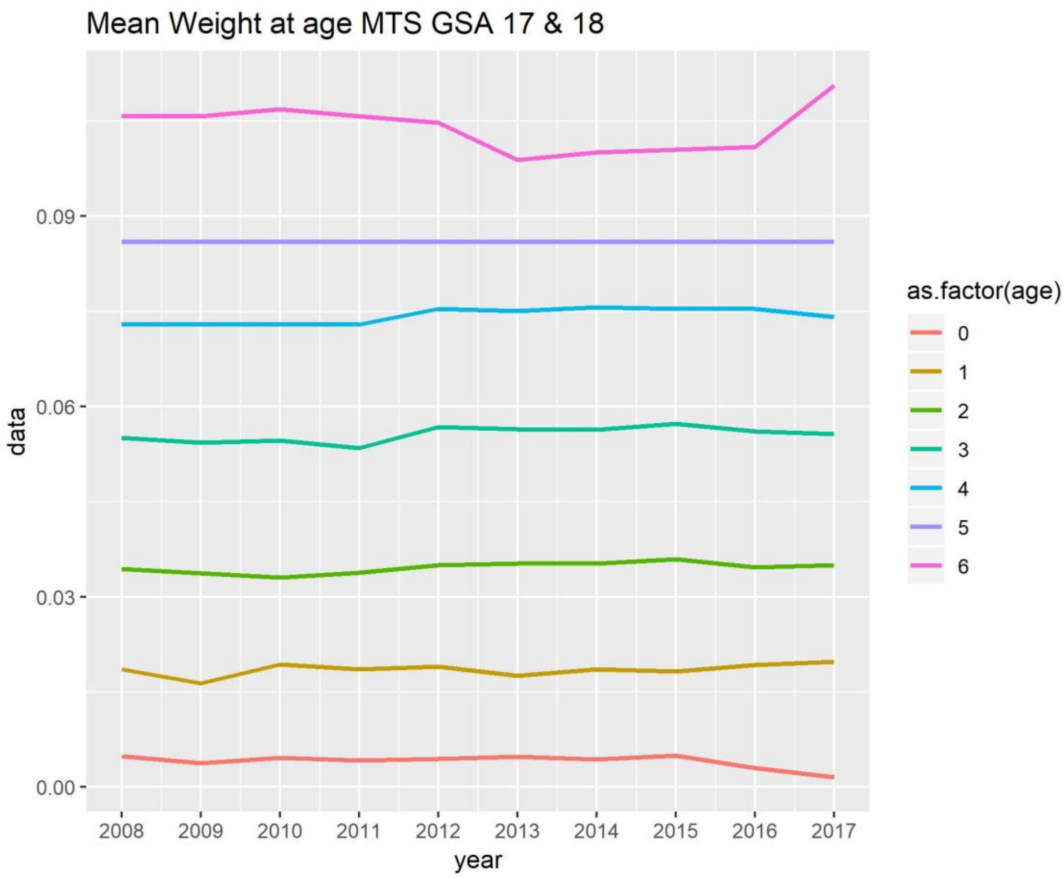


Figure 6.7.3.3 Spottail mantis shrimp in GSAs 17 and 18. Mean weight at age.

6.7.3.1 A4A ASSESSMENT RESULTS

Different a4a models were performed (combination of different f, q and sr). The best model (according to residuals and retrospective) included:

```
fmodel <- ~ factor(replace(age, age>4,4))+s(year, k=5)
qmodel<- list(~ factor(replace(age, age>4,4)))
srmod <- ~s(year, k = 6)
```

Results are shown in figures 6.7.3.4 – 6.7.3.6, namely the estimated recruits, spawning stock biomass catch and harvest rates for ages 1 - 3. Fishing mortality through all ages and years and catchability of the gear of the SOLEMON survey tunning index:

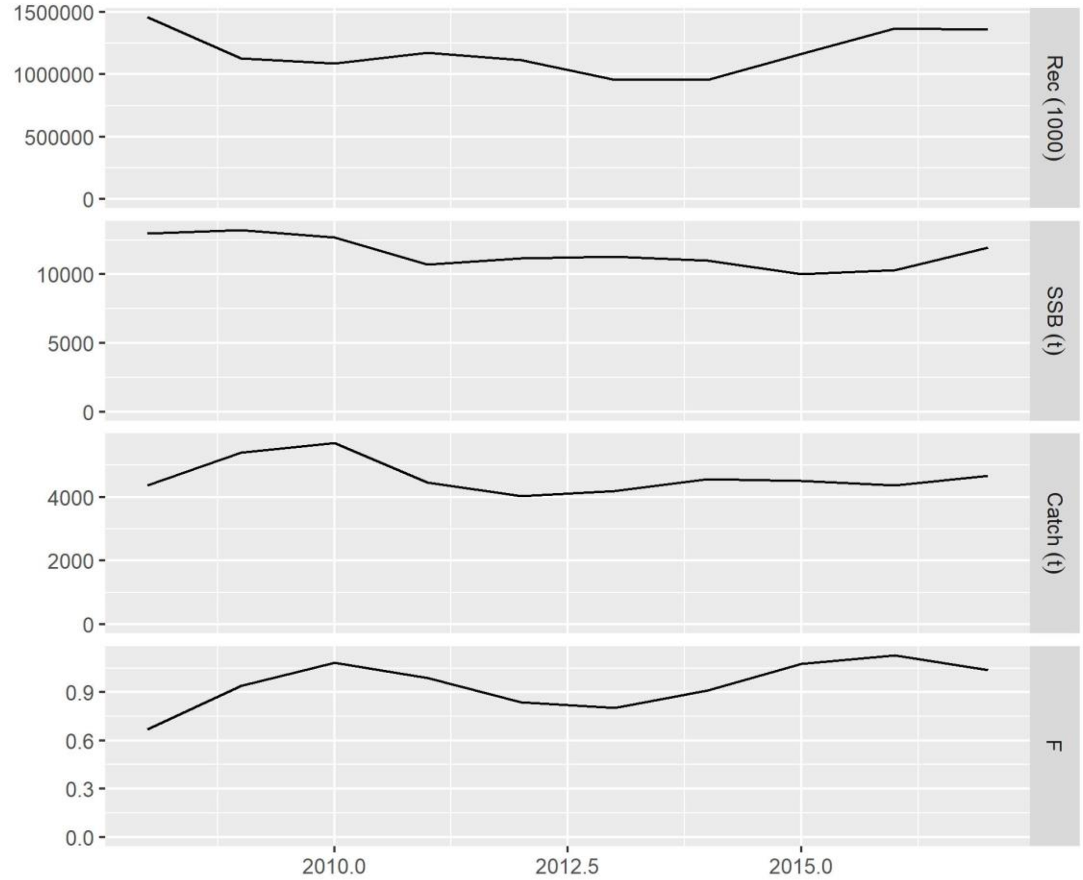


Figure 6.7.3.1.1 Spottail mantis shrimp in GSAs 17 and 18. Stock summary from the a4a model for Spottail mantis shrimp in GSAs 17 and 18, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

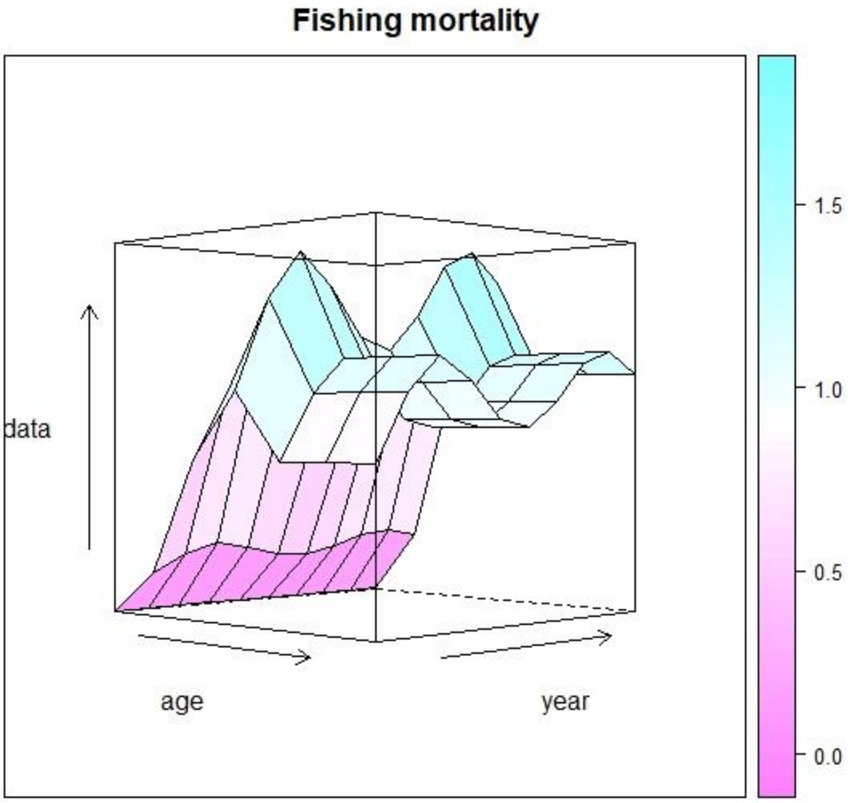


Figure 6.7.3.1.2 Spottail mantis shrimp in GSAs 17 and 18. 3D contour plot of estimated fishing mortality by age and year.

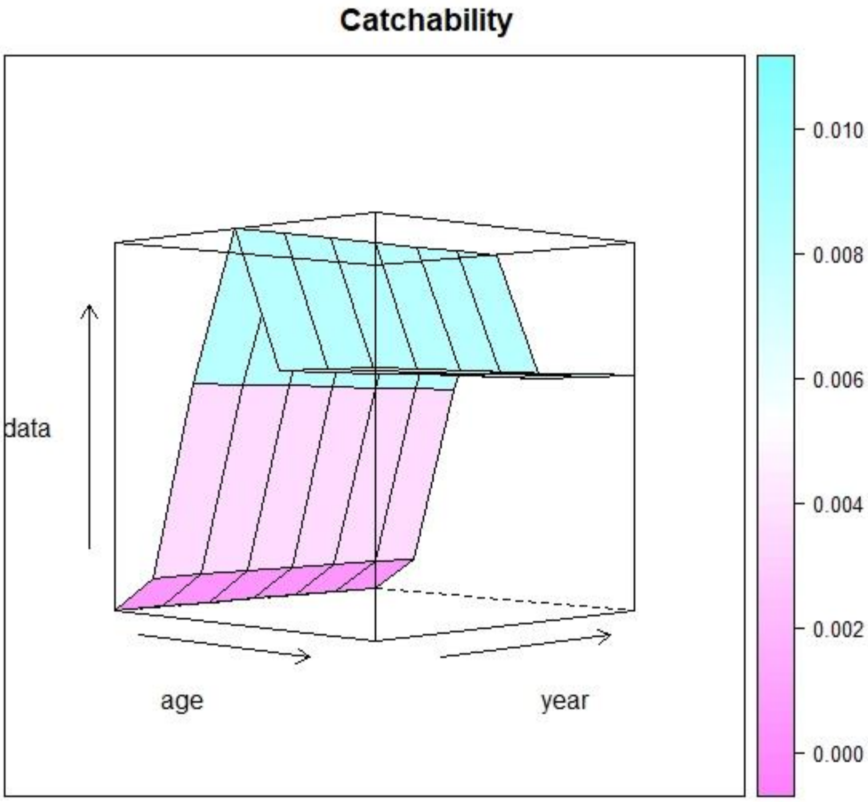


Figure 6.7.3.1.6 Spottail mantis shrimp in GSAs 17 and 18. 3D contour plot of estimated catchability by age and year.

Diagnostics

Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of Spottail mantis shrimp stock. Residuals of the total catch showed a descending trend. It was not possible to reach to a better fit without smoothing too much the model or assuming an unrealistic fishing mortality. So the STECF EWG 18 -16 decided to keep the specific settings for the a4a model. Residuals at age in the catch and the survey do not show problematic effects, they are wellscattered positive and negative values in the catch and the occasional year effect in the survey.

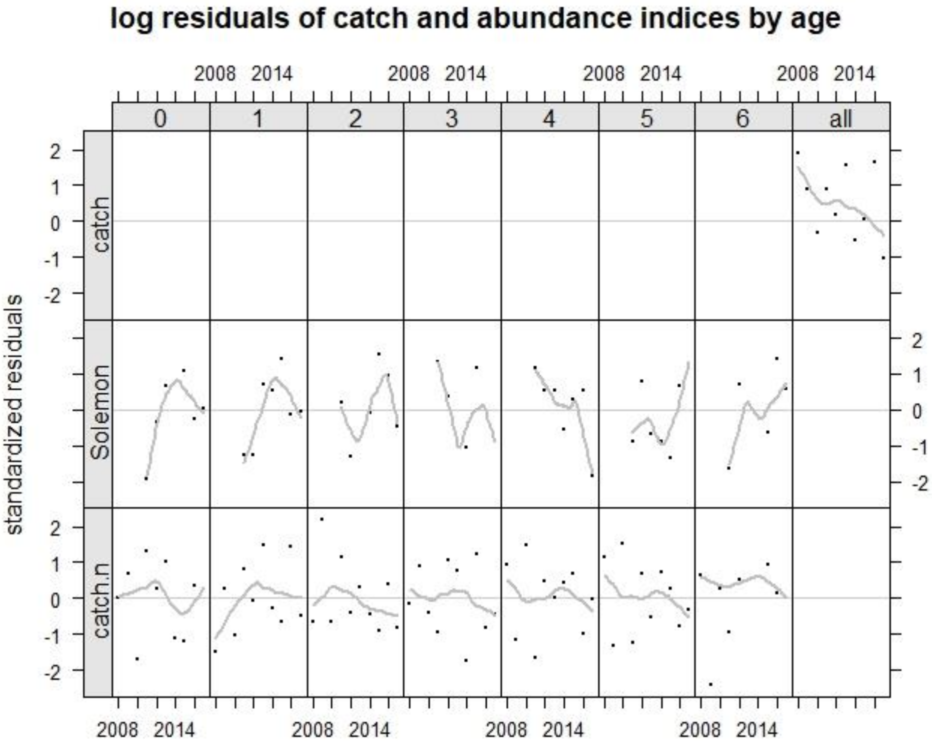


Figure 6.7.3.1.3 Spottail mantis shrimp in GSAs 17 and 18. Standardized log residuals for the fitted model for catch numbers at age, index abundances and total catch.

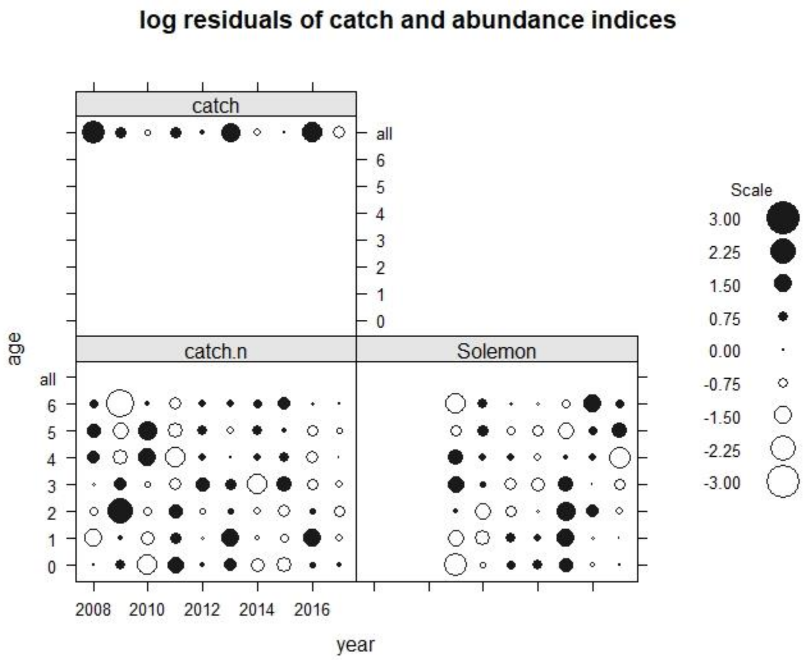


Figure 6.7.3.1.4 Spottail mantis shrimp in GSAs 17 and 18. Standardized log residuals for the fitted model for catch numbers at age, index abundances and total catch presented in a bubble plot.

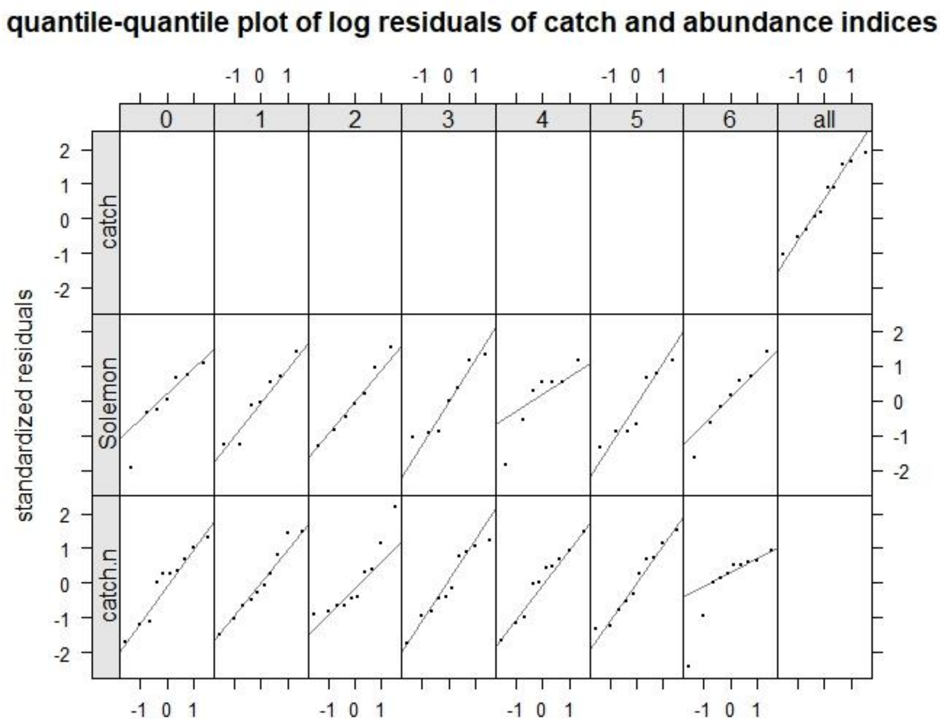


Figure 6.7.3.1.8 Spottail mantis shrimp in GSAs 17 and 18. Standardized log residuals for the fitted model for catch numbers at age, index abundances and total catch presented in a quantile – quantile plot.

Fitted versus observed catch at age (Figure 6.7.3.9) show a fairly good fit for the model to the data. Some problems are apparent in the years 2013 and 2016 mainly in the age 1.

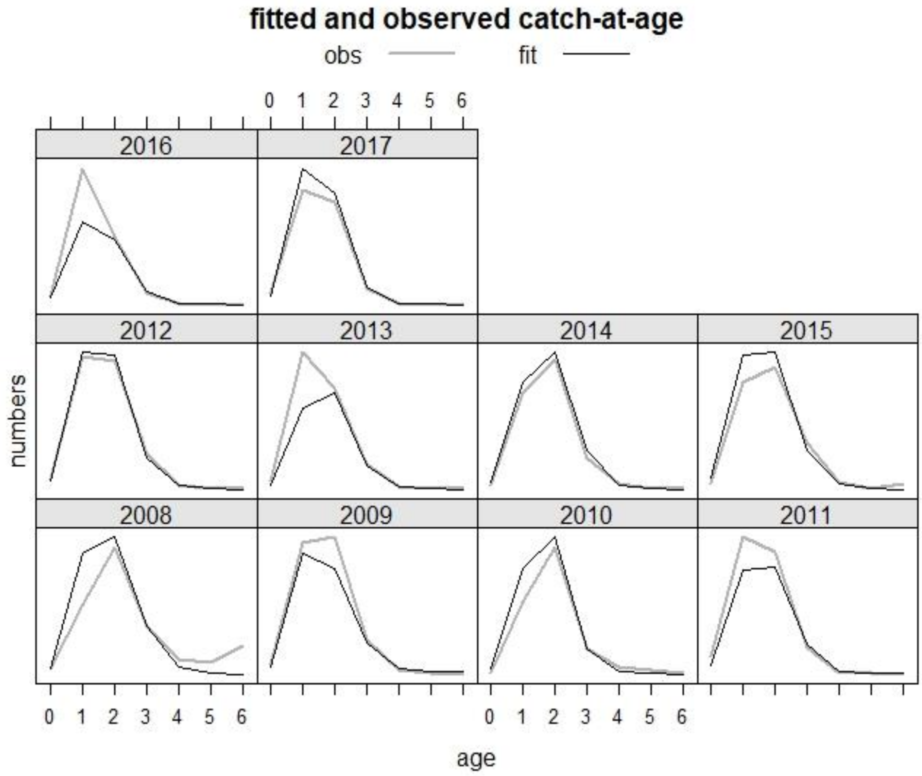


Figure 6.7.3.1.5 Spottail mantis shrimp in GSAs 17 and 18. Estimated versus observed catch at age.

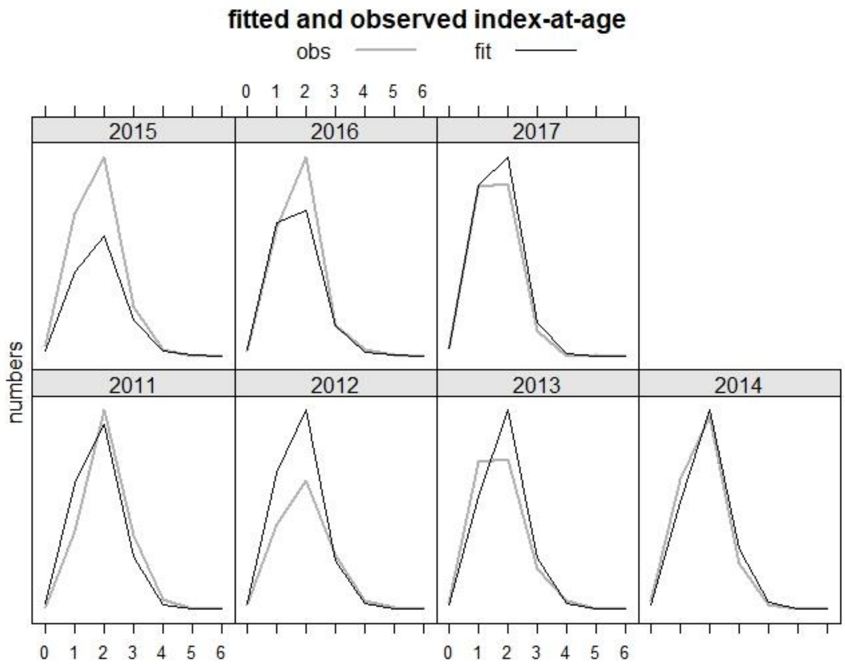


Figure 6.7.3.1.6 Spottail mantis shrimp in GSAs 17 and 18. Estimated versus observed index at age.

Retrospective

Retrospective plots seemed quite unstable especially for the recruitment. Fishing mortality seem to be lower in the previous years by 0.1 for each retrospective run, but being constistantly above the proxy of Fmsy, f0.1.

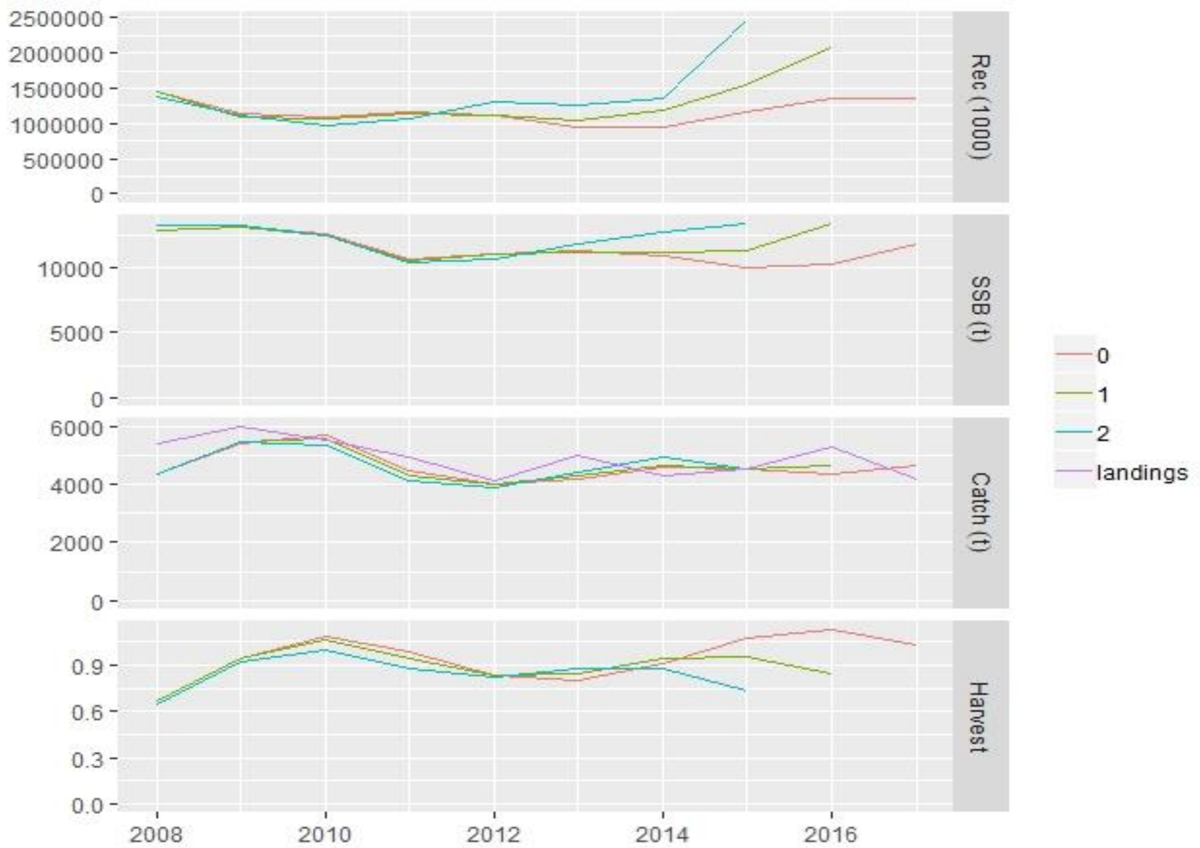


Figure 6.7.3.1.7 Spottail mantis shrimp in GSAs 17 and 18. Retrospective analysis for the a4a model.

Simulations

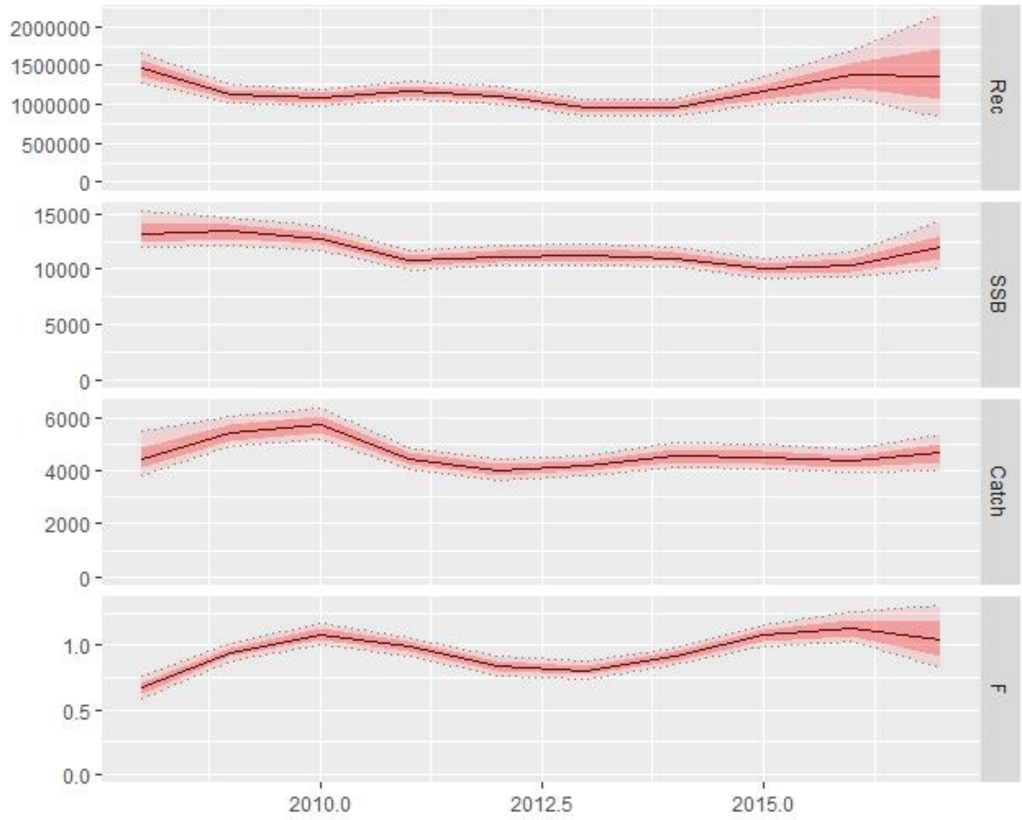


Figure 6.7.3.1.8 Spottail mantis shrimp in GSAs 17 and 18. Stock summary of the simulated and fitted data for the a4a model.

Table 6.7.3.1.1 Spottail mantis shrimp in GSAs 17 and 18. Stock summary results for a4a model.

year	recruitment (1000)	ssb (t)	catch (t)	fbar(1-3)	tb (t)
2008	1458099	12958	4365.3	0.66846	21260
2009	1129913	13224	5387.7	0.94123	18826
2010	1086219	12700	5703	1.08448	18946
2011	1173017	10730	4445.4	0.9878	16789
2012	1115005	11146	4023.8	0.83718	17370
2013	958833	11300	4180.6	0.80325	16964
2014	958635	11018	4567.5	0.91242	16194
2015	1167007	10028	4513.1	1.07653	16787
2016	1367724	10290	4362.3	1.12899	15620
2017	1361547	11935	4672.5	1.03795	15649

Based on a4a results spawning stock biomass of Spottail mantis shrimp fluctuated around 11000 tonnes with a slight increasing trend the last three years. Catch is around 4000 tonnes the last five years with the maximum appearing in 2010 early in the time series. The recruitment was in maximum levels in the beginning of the time series in 2008 while Fbar fluctuated the last three years with an fbar in 2017 1.04.

Table 6.7.3.1.2 Spottail mantis shrimp in GSAs 17 and 18. Harvest at age.

	F at age						
	0	1	2	3	4	5	6+
2008	0.0045628	0.204436	0.747268	1.05368	0.740387	0.740387	0.740387
2009	0.0064247	0.287857	1.05219	1.48364	1.04251	1.04251	1.04251
2010	0.0074025	0.331667	1.21233	1.70944	1.20117	1.20117	1.20117
2011	0.0067426	0.302099	1.10425	1.55704	1.09408	1.09408	1.09408
2012	0.0057145	0.256035	0.935876	1.31963	0.927258	0.927258	0.927258
2013	0.0054829	0.245659	0.897949	1.26615	0.889681	0.889681	0.889681
2014	0.006228	0.279045	1.01998	1.43822	1.01059	1.01059	1.01059
2015	0.0073482	0.329237	1.20345	1.69691	1.19237	1.19237	1.19237
2016	0.0077063	0.345279	1.26209	1.7796	1.25047	1.25047	1.25047
2017	0.0070849	0.317436	1.16031	1.63609	1.14963	1.14963	1.14963

The EWG 18 – 16 concluded that the a4a model was suitable to provide the basis of the current status of the stock.

6.7.3.2 XSA ASSESSMENT RESULTS

The analysis was performed with scripts made available by JRC.

Input data come from DCF. XSA input data are the same as used in the a4a assessment. The assessment was done for the period 2008-2017.

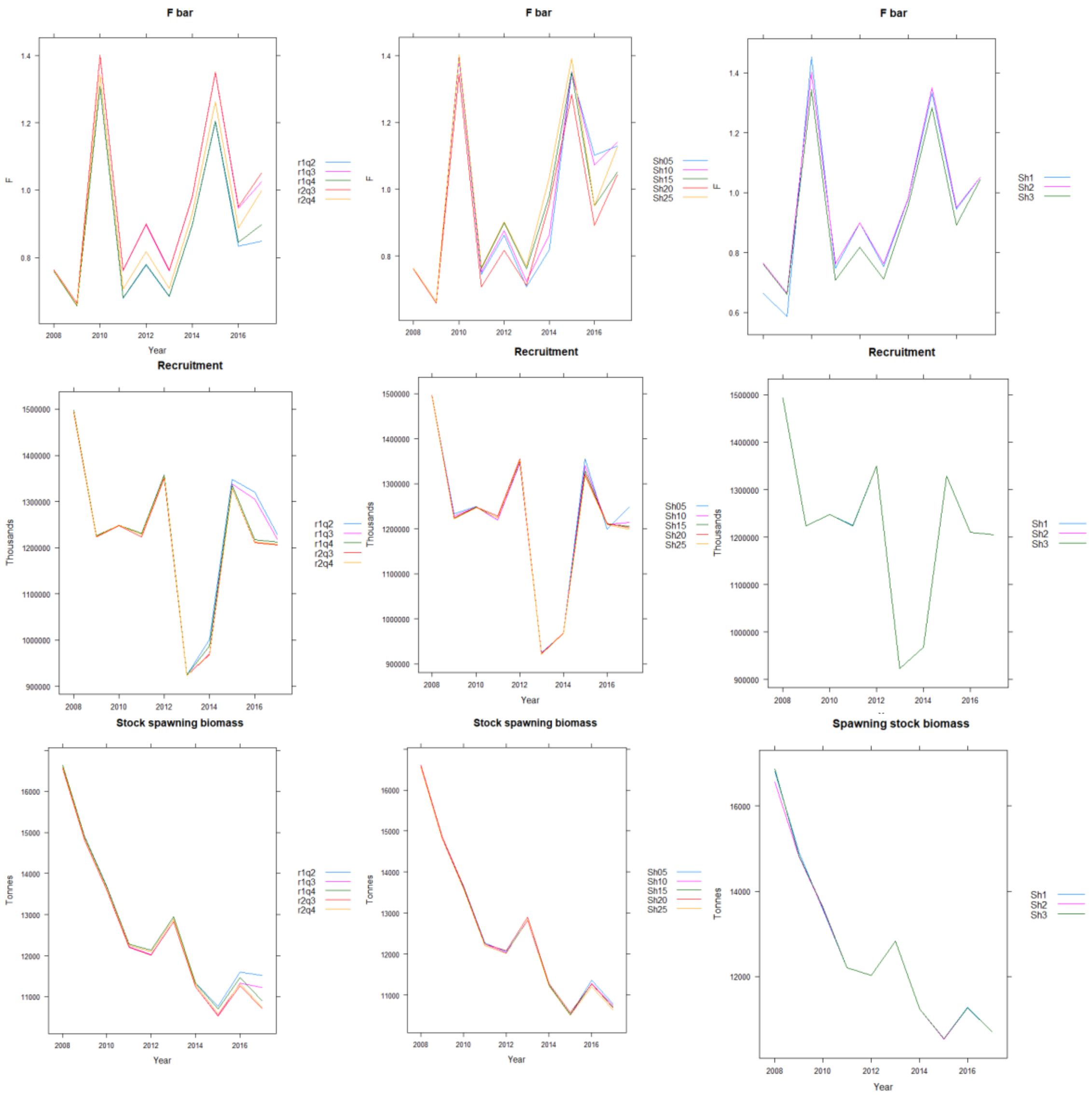


Figure 6.7.3.12 Spottail mantis shrimp in GSAs 17 and 18. Sensitivity analyses considering different combinations for shrinkage.

Sensitivity analyses were performed to select the final XSA run, considering different combinations for shrinkage. The following settings were selected, based on the retrospective performance and the residuals pattern of SOLEMON survey:

fse=1.5, rage=0, qage=3, shk.n=TRUE, shk.f=TRUE, shk.yrs=3, shk.ages=3

Table 6.7.3.9 Spottail mantis shrimp in GSAs 17 and 18. Residuals table.

age	2011	2012	2013	2014	2015	2016	2017
0	-1.917	-0.212	0.128	0.283	1.280	0.110	0.328
1	-0.541	-0.474	0.191	0.276	0.504	-0.008	0.052
2	-0.086	-0.530	-0.231	-0.119	0.583	0.322	0.060
3	0.363	-0.065	-0.387	-0.374	0.440	0.144	-0.121
4	0.187	0.287	-0.339	-0.850	-0.086	0.040	-0.990
5	0.000	-0.055	-0.063	-0.516	-0.399	0.109	0.100

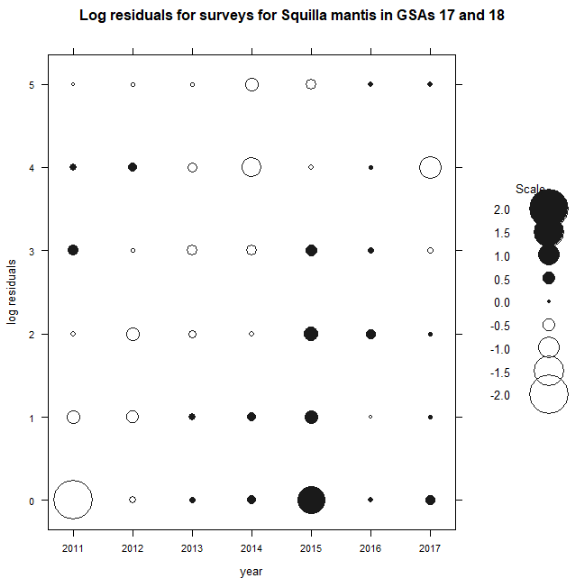


Figure 6.7.3.13 Spottail mantis shrimp in GSAs 17 and 18. Residuals pattern of SOLEMON survey.

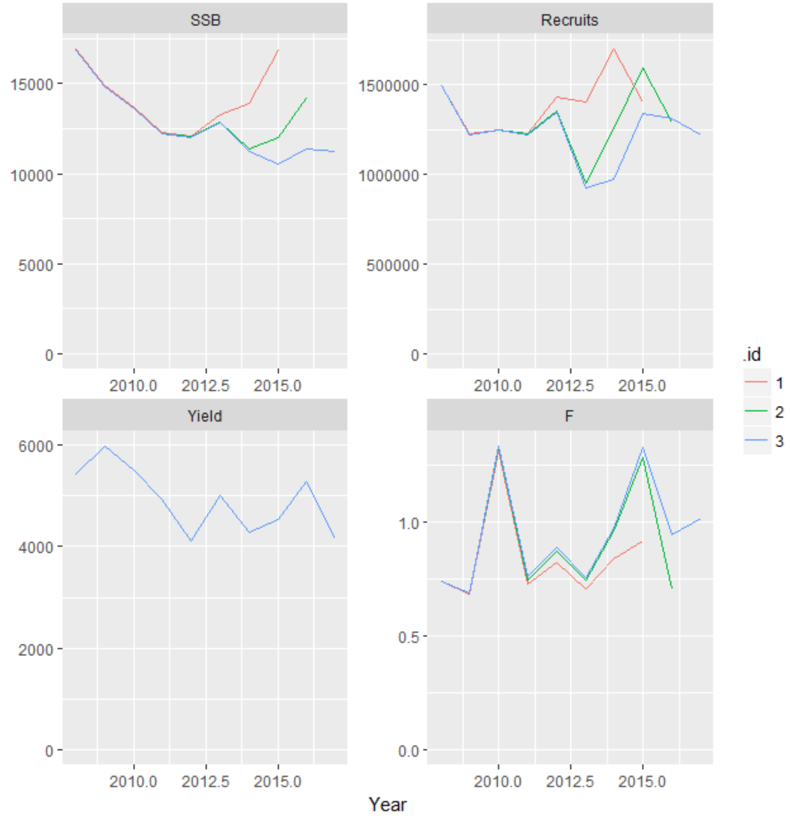


Figure 6.7.3.14 Spottail mantis shrimp in GSAs 17 and 18. XSA retrospective analysis.

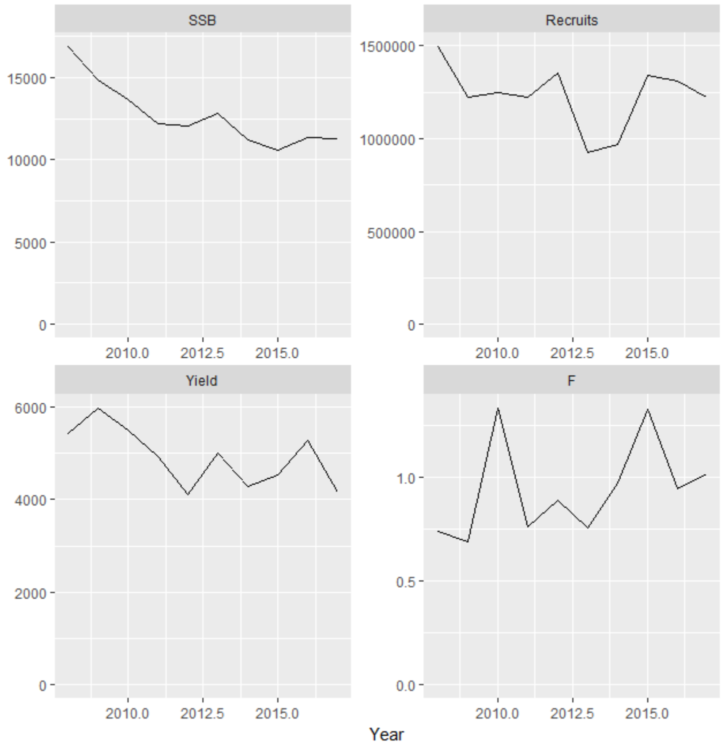


Figure 6.7.3.15 Spottail mantis shrimp in GSAs 17 and 18. XSA assessment summary results.

Table 6.7.3.10 Spottail mantis shrimp in GSAs 17 and 18. XSA assessment summary results. Biomass, catch and SSB in tonnes, recruits in thousands, F_{bar} ages 1-3.

	Biomass	Catch	SSB	Recruits	Fbar
2008	25489	5423	16860	1493072	0.52
2009	20816	5978	14830	1223520	0.95
2010	20727	5501	13638	1247893	1.11
2011	18663	4933	12212	1224050	1.00
2012	19340	4112	12027	1350320	0.81
2013	18564	5011	12834	923209	0.87
2014	16430	4292	11243	971173	0.79
2015	18177	4537	10553	1339050	1.20
2016	16691	5272	11339	1309161	1.28
2017	14684	4157	11260	1224193	1.12

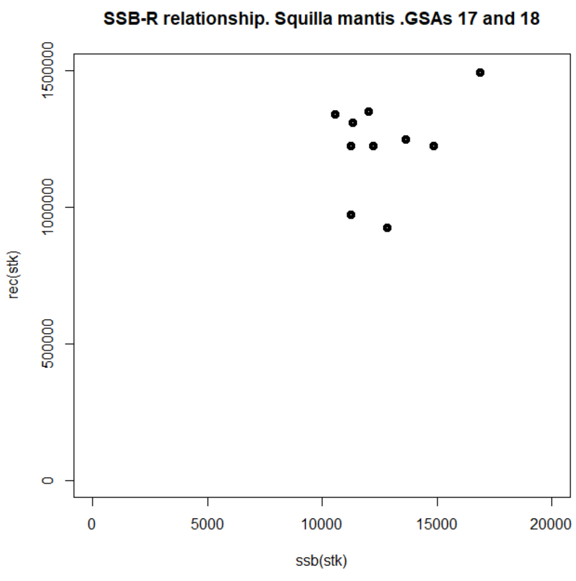


Figure 6.7.3.16 Spottail mantis shrimp in GSAs 17 and 18. SSB-R relationship. Spottail mantis shrimp does not display an apparent SSB-R relationship.

From XSA results, F_{ref}=mean $F_{(1-3)}$ (2015-2017)=1.2; and $F_{0.1}$=0.40. According to these values, F/ $F_{0.1}$=3.0.

6.7.4 REFERENCE POINTS

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as F_{max} and $F_{0.1}$. Yield per Recruit computation was made using R project software and the FLR libraries. The fishing mortality rate corresponding to $F_{0.1}$ in the yield per recruit curve is considered here as a proxy of F_{MSY}.

The input parameters were the same used for the a4a stock assessment and its results.

In a4a and XSA runs the F0.1 was estimated using FLBRP package and the values estimated were, respectively, 0.40 and 0.41.

EWG 18-16 decided that the a4a model was the most suitable to estimate the status of the stock of Spottail mantis shrimp. Fbar calculated as the mean of the last three years is 1.08, thus F/F0.1 = 2.6 and the stock is considered overexploited. The results from the XSA assessment are very similar giving a slightly higher F/F0.1 (=2.9).

6.7.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2018 to 2020 was performed using the FLR routines provided by JRC and based on the results of the a4a stock assessments performed during EWG 18-16.

The input parameters were the same used for the a4a stock assessment and its results. F status quo is equal to mean of the last three years, corresponding to a catch2018 of 2742 t. Recruitment 2018 and 2019 is 1295293 thousands (equal to the geometric mean recruitment of the last three years).

Table 6.7.5.1 Spottail mantis shrimp in GSAs 17 – 18. Short term forecasts showing catch options for different fishing mortalities reductions.

	Ffactor	Fbar	Catch2019	Catch2020	SSB2019	SSB2020	SSB change 2019-2020(%)	Catch change 2017-2019(%)
zero catch	0.00	0.00	0	0	12832	18654	45.37	-100.00
F0.1	0.40	0.41	2742	3658	12832	15538	21.08	-41.32
status quo	1.00	1.04	5406	5291	12832	12622	-1.64	15.70
Different scenarios of F	0.10	0.10	787	1289	12832	17751	38.33	-83.16
	0.20	0.21	1501	2287	12832	16937	31.98	-67.88
	0.30	0.31	2151	3060	12832	16201	26.25	-53.96
	0.40	0.42	2744	3660	12832	15536	21.07	-41.27
	0.50	0.52	3286	4125	12832	14932	16.36	-29.67
	0.60	0.62	3783	4487	12832	14382	12.08	-19.03
	0.70	0.73	4239	4769	12832	13882	8.18	-9.27
	0.80	0.83	4660	4988	12832	13424	4.61	-0.28
	0.90	0.93	5047	5158	12832	13006	1.35	8.02
	1.10	1.14	5739	5395	12832	12268	-4.40	22.82
	1.20	1.25	6048	5476	12832	11942	-6.93	29.43
	1.30	1.35	6335	5539	12832	11641	-9.28	35.59
	1.40	1.45	6604	5589	12832	11362	-11.45	41.33
	1.50	1.56	6855	5628	12832	11104	-13.47	46.71
	1.60	1.66	7091	5658	12832	10863	-15.35	51.75
	1.70	1.76	7312	5682	12832	10638	-17.10	56.49
	1.80	1.87	7520	5700	12832	10428	-18.74	60.94
	1.90	1.97	7716	5715	12832	10231	-20.27	65.15
	2.00	2.08	7902	5727	12832	10047	-21.71	69.12
fupper	0.55	0.57	3524	4306	12832	14668	14.31	-24.58
flower	0.27	0.28	1941	2824	12832	16438	28.10	-58.45

7 DATA QUALITY AND DEFICIENCIES BY STOCK

ToR 9. As a matter of priority, the EWG is requested to ensure that all unresolved data transmission (DT) issues encountered prior to and during the EWG meeting are reported on line via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt. Guidance on precisely what should be inserted in the DTMT, log-on credentials and access rights will be provided separately by the STECF Secretariat focal point for the EWG.

The EWG is also requested to summarize and concisely describe all data deficiencies, in terms of coverage, quality and timeliness, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched in 2018.

7.1 HAKE IN GSA 17-18

The data used for the analyses come from the last EU DCF official data call (2018). the data related to non-eu countries (Albania and Montenegro) was taken by the GFCM WGSAD official report. LFDs from GSA18 (Italy) were available from 2002 (with a gap in 2006); as concerns GSA17, LFDs from Italy were available from 2006, and from 2013 for Croatia. however, LFDs from 2008 were available for Croatia from GFCM WGSAD. for Italy (both gsa17 and 18), the time period of the survey has changed in some years. however, this should not represent a major issue for the abundance estimate of European hake.

7.2 RED MULLET IN GSA 17-18

The data used for the analyses come from the last EU DCF official data call (2018). The data related to non-EU countries (Albania and Montenegro) was taken by the GFCM WGSAD official report. Landing data before 2006 was lacking for gsa 17 (Italy). LFDs data for GSA18 (Italy) were not available in 2006. in Italy, MEDITS survey in both GSA 17 and 18 was performed in a later period than the usual one in several years, and especially in 2017.

7.3 NORWAY LOBSTER IN GSA 17-18

In GSA17 (ITA) NEP (Norway lobster) landings by length and weight are available from 2006 onward. Previous years are missing (2002-2005)

In Croatian (HRV) MEDITS TC file NEP (Norway lobster) length measures are reported in the wrong unit in 2016

In GSA17 (Italy) landings distribution by length change a lot in term of order of magnitude from 2006, 2007-2011, and from 2012 onward. In respect of this huge variation in number landings in weight in the first part of the series seem more stable.

In GSA18 (Italy) for NEP (Norway lobster) discards in weight in 2009 seems very high compare with the whole series.

In GSA18 (Italy) landings by length distribution for NEP (Norway lobster) in year 2006 is missing.

7.4 Deep-water rose shrimp in GSA 17-18-19

The data used for the combined assessment of DPS in GSAs 17-19 come from the last DCF official data call (2018). For some fleet and year both landings and discards data were incomplete. For the purposes of the assessment EWG 18-06 reconstruct missing data taking in to account all the available information to fill gaps by fleet (i.e. By GSA, country and gear) and for some years the previous STECF EWG 17-09.

The main gaps in landings and discards are described hereafter.

For GSA 17 Italian landings were continuosly reported from 2013, while apart some year (2006 and 2011) data were not reported. For Croatia landings were reported in the DCF database from 2014 onward, because previously there was no obligation to monitor that species.

For GSA 18 landings were incomplete for Albania and Montenegro. Landings data for Albania were obtained from last STECF-EWG (17-09) for some years (2007-2009) and from FISHSTAT from 2010 onward. Also for Montenegro data were taken from last STECF-EWG (17-09, originally derived from the GFCM assessment in 2017).

Landings data for GSA 19 were complete.

Discards were reported through DCF for GSA 18 and GSA 19 since 2010, for GSA 17 in 2006, 2011 and 2013-2017 for Italy and since 2008 for Croatia; no information was available neither for Albania nor for Montenegro.

7.5 Common cuttlefish in GSA 17-18

EWG18-16 noticed problems/biases in effort data, and it has been explained and reported on line via the data transmission monitoring tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt.

Due to the fact that area concerned (Adriatic sea, GSA 17 and GSA 18) occupy non-EU waters that belongs to non-EU countries (Albania and Montenegro) also, the EWG18-16 faced with difficulties to obtain complete catch/landing datasets of common cuttlefish. Inconsistency is notable in historical catch data considering that this species was usually reported together with other species from families *sepiidae* and *sepiolidae* (e.g. *S. elegans, S. orbignyana, Rossia macrosoma*, etc.) or was not reported at all. therefore, to obtain the most complete data on common cuttlefish catch, EWG 18-16 had to consider other data sources (beside DFC data) also, as described in section 6.5.2.1. significant difficulty was the interpretation of the data obtained through the GFCM FISHSTAT database in which landings from GSA 18 belongs to 37.2.2 (Ionian) statistical division of Mediterranean area. The stated difficulty probably affected the previous results of stock assessment of common cuttlefish (EWG 17-15).

Growth parameters of common cuttlefish in the adriatic sea area are scarce. Data on size structure were available for bottom trawl, set nets and FPO (pot and traps) fisheries, only from Italian side since 2006 (2007 in GSA 18). In addition, different MEDITS survey periods had an adverse effect on quality of survey data used as tuning index, by adding some uncertainties in abundance indices and distribution patterns data series.

7.6 Sole in GSA 17

The data used for the a4a model come from the last DCF official data call (2018). The croatian total landings and length frequency distribution (LFD) data were lacking for years before 2012 and they were reconstructed on the basis of the total landings also used in the EWG 17-15 from FAO FISHstat. Slovenian LFDs data were lacking and were reconstructed on the basis of the LFDs of the Croatian catches after 2011. Italian total landings and LFDs were missing for 2009 and 2010 for gillnets data and between 2007 and 2010 for otter trawl data. These were reconstructed as averages from the years before and after the missing interval.

Catch at age data submitted to the DCF of 2018 were used to update the ss3 model but were not considered reliable by the EWG 18-16 due to internal inconsistencies and communications from Italian and Croatian experts that otholits reading are being recalibrated and not considered reliable anymore. The EWG 18-16 therefore asks that Member States involved in the revision of sole age estimation in GSA 17, to submit an official communication on the reliability of the data.

7.7 Spottail mantis shrimp in GSA 17-18

Spottail mantis shrimp total landings data from Italy were not reported for Italy in GSA 17 until 2007 as well as the corresponding length frequency distribution. discards data from Italy in GSA 17 were not reported until 2010.

Croatian data for spottail mantis shrimp were not available neither in landings or discards in the DCF database.

Landings data for GSA 18 from Italian side were not available until 2006 while discards data were only available after 2009. Length frequency distribution were not available until 2007.

According to tor 9, the EWG 18-16 reported on line via the data transmission monitoring tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt.

8 References

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9 ANNEX A COMMENTS FROM STECF MEMBER ON THE EWG REPORT AND RESPONSES AND NOTES OF ACTIONS FROM EWG.

The original comments are given in black type below. The responses from the EWG are included interspersed in blue type, these indicate where changes in the report have been made and what further actions are proposed for the future.

Although, I truly believe that EWG 18-16 experts performed the best possible analyses on the list of stock proposed in the ToRs, after reading the report during the STECF-PLEN 18-03, the following general and stock specific concerns preclude my full support to the conclusion of the EWG 18-16:

> 1 – The stock configurations for red mullet, Norway lobster, common cuttlefish and spottail mantis shrimp are not well justified. According to the EWG 18-16 ToRs joint assessments have been proposed on the basis of STOCKMED and management needs. However, the ToRs also state that these suggestions can be modified according to experts' knowledge and to the most recent scientific information. Regarding red mullet, Matić-Skoko et al. (2018), suggested that there significant genetic differences in samples collected in different areas of GSA 17 and GSA 18, which implies that the two area should be better assessed separately. Norway lobster in the Adriatic has large differences in growth between the Pomo pit and the rest of the Adriatic basin (see STECF, 2016; EWG 16-08). In such cases, precautionary approach should be invoked and the areas should be assessed separately to avoid risk of depletion of the smallest stock (Frank and Brickman, 2010). Finally, there is no evidence that stocks of common cuttlefish and spot-tail mantis shrimp should be assessed combining GSAs 17-18.

The EWG considered the data issues for separate assessments of some of these species, for some it's possible to separate fisheries data by GSA but for others there are fleets that land into GSA 18 may fish in GSA 17. For the future it may be possible to use VMS data to improve the situation, but for now it is unclear if there are real benefits to increasing the number of assessments. For Nephrops this point is recognised and extensive work initiated to explore sensitivity to of an age based assessment to growth assumptions. However, due to the uncertainty of the allocation of landings data to location it is not possible to split catches fully. There have been some attempts to provide multi area, Nephrops assessments, but these have not been successful.

In the case of Nephrops and Red Mullet where the issues are better documented STECF refers to these issues in the advice. Matić-Skoko et al. (2018) reported that "Adriatic populations, previously considered panmictic and isolated from other Mediterranean regions, showed geographical partitioning within the basin but also population connectivity with the northern Ionian and Tyrrhenian Seas". The authors however, also "highlight the need for temporal sampling in understanding the complex pattern of population connectivity in the Mediterranean, particularly for management purposes." Currently it's unclear if a separate assessment would be superior. The WG will keep examining possibilities for single GSA assessments. If resources are available, the assessments that could be split by GSA reporting areas could be trialled to evaluate the consequences. Overall it is noted that a multi stock unit assessment correctly evaluates the mean exploitation rates across the area. There may also be potential to split biomass according to MEDITS data, to infer GSA level depletion.

The EWG agrees there is no evidence that stocks of common cuttlefish and spot-tail mantis shrimp should be assessed combining GSAs 17-18, but equally note there is no evidence to the contrary.

2 – It is noted that surveys from different GSAs and MS are combined. While this constitutes a pragmatic approach, it should be carefully tested in the framework of each stock assessment, taking into account the differences in survey timing that had occurred. Moreover, MEDITS standardisation assumes that neither the period, nor the spatial distribution of the hauls changes over time. However, these assumptions are both violated for most of the cases, and therefore invalidating the tuning indices used for the assessments. In the case of changes in both timing of the survey and spatial distribution of the hauls, the correct way to produce the survey index to be used in the assessment models would be through a GLM, GAM, GAMM or spatial models (Berg and Kristensen, 2018).

The EWG has considered carefully all cases where surveys have been combined, and has presented specific information on the general principles of survey combination. The main point is that fitting multiple surveys separately, the practice employed previously does not deal the kind of errors detailed. Nor indeed does the cited method, which concentrated in normalising surveys with a lack of standardisation, not how 'migration related errors' are addressed in assessment models. The issue is that there is no information in the data to inform the model about migration, so one looks for the solution least likely to be sensitive to this. Thus the important point is to use a combined survey. If the surveys being combined have the same underlying statistical properties, which is the case for subsets of MEDITS survey, the most effective way to combine these is with equal area weighting. Only if the statistical properties are importantly different would other approaches be applicable. The weighting methods suggested are designed to deal with that situation, and with missing data. While some MEDITS surveys might be improved by modelling changes in survey design, the improvements are likely marginal.

3 - It is noted that when length slicing is carried out using a growth curve, t_0 can be modified by adding the fraction of the year before spawning to have more reliable data for stock assessment carried out using calendar year. While this approach might be correct, it should be carefully tested in the framework of each stock assessment. Moreover, as stated in the report the adjustment in t_0 is likely to have minor effects for long lived species with few young individuals in the assessment (e.g. *Nephrops*), as any error in t_0 becomes less important if the species live longer. However, this approach has been used also for Sole in GSA 17, which is not appropriate.

The use of alignment of origin (t=0) of growth curves is discussed in detail in both MED Pt I and MED Pt II. The problem with the use of calendar year assessments and growth started at 1st of January was considered carefully. If the growth curve is specified based on true growth from a spawning time, but the spawning time is occurring at a different point in the year, the model will be more inaccurate if the problem is ignored. However, it's acknowledged that before correction for this issue it is necessary to full understand the basis of the ageing used in the growth data. The age transition lengths (e.g. $L_{age\ 0\text{-}1}$, $L_{age\ 1\text{-}2}$) were carefully checked before using T0 corrected length models. Sole was not treated in this way, see section below.

Concerns for each stock.

4 – For Hake GSA 17-18, natural mortality vector has been estimated using Chen and Watanabe formula. Such approach it is not ideal for long-lived species as hake and the methods developed by Then et al., (2015) should be considered. Moreover, catchability in a4a model seems to be dome shaped but no justification was provided.

The choice of natural mortality for all species is an issue for modelling fish stocks. The WG always discusses this issue at every meeting and will continue to do so, the publication referred to (Then et al., 2015) along with others will be considered further at the hake benchmark. Please see also the review section for hake which discussed overall mortality issues, and the difficulties resolving this issue.

In all cases for hake in 17-18 the shape of selection patterns has been examined closely in the EWG and is discussed to some extent in the model review section. It is clear from the fishery data where there are specific fisheries/fleets that catch the larger individuals at a different rate from the trawl gears that catch smaller individuals. From discussions in STECF PLEN 18-01 it should be clear that domed shaped selection has been carefully reviewed in both SS3 and a4a models. It's clear from the data that MEDITS survey does not catch the largest individuals, and that longline and gillnet and trammel net fisheries catch larger individuals than the trawl fisheries. As these fisheries obtain small catches relative to the trawl fisheries, they strongly support lower partial Fs. Evaluations by simulation of spatially diverse and muti-gear fisheries show these always result in some overall doming in the combined selection patterns. The problem is to determine the extent of the doming. The issues have been well considered at the EWG and are discussed in the hake review section.

> 5 – For red mullet GSA17-18, is stated: "*a change in survey catchability from 2012, due to a change in the survey period, and a change in the behaviour of the fleet from 2014, due to the enforcement of the regulation that does not allow fishermen to fish within the 3 nautical miles (where the smaller individuals are generally distributed). A specific term in the F sub-model is dedicated to the fitting of the F at age* 0". The change in survey timing occurs not only in 2012 (also before and after) and also the Italian fleets are not allowed to fish within 3 nm before 2014. Therefore, the justifications provided in the model setting are not clear and not well justified.

The EWG disagrees with the assertion that this change with time was not well justified, as indicted by the comment made it is clear that some change has occurred, and the shift in survey timing is well documented in the report. The EWG considered several ways to allow more flexibility in the model and found that this was the most effective method. The EWG will try to document the extent of this exploration more fully in the future.

> 6 – For Norway lobster GSA 17-18, attempts with analytical approaches (a4a) were carried out using sliced length distribution for the whole area by means of alternatively growth parameters (within Pomo, outside Pomo). Results are quite different, suggesting that the use of this stock configuration would be not ideal in the production model. Also, as stated before, there could be a risk of depletion of the smaller stock in case management advice is based on the present stock configuration (i.e. both stocks merged). Finally, from the report it is not completely clear how the F target of 0.35 has been estimated.

The approach was fully explained as a sensitivity test not an alternative assessment. The STECF advice takes account of the issues described above; there is no satisfactory multi-area model available in the EWG or in GFCM or published elsewhere. The EWG will continue to monitor the situation and look at ways improve the Nephrops advice, but currently the best model to inform on the exploitation rate and biomass status for this stock is the production model (i.e. SPICT).

The basis of the STF target is explicitly noted in the reference point table in section 5.

7 – For deep-water rose shrimp in GSA 17-19, the SOP corrections are high in some year evidencing a potential problem in the slicing procedure or in the estimate of the L-W relationships. The trend of SSB estimated by a4a shows a stable pattern with the exception of 2003 and 2006 when the SSB was around 13 times the SSB observed in the other years, which is clearly unrealistic and indicated a model misspecification or severe data issues.

The Albanian landings update has been included; the EWG available in draft to the STECF has been updated to explicitly state this. The effect is a 3.5 to 5 fold increase in reported Albanian landings from 2012 to 2017, increasing total catches by +50% in 2012 reducing to +25% in 2017, as overall catches are seen to increase. The EWG discussed this and there did appear to be an increase in Albanian effort during this period, though the full extent of the catch increases and the validity of the landings values could not be verified. The issue of the Albanian updates is explicitly dealt with in the STECF advice. The EWG report has been updated to make this clear. The SOP factors include the use of 'fill in' for fleets without sample (LFD data), as this raises catches without samples to the full catch in a simple manner considered suitable for this species. They therefore do not come from 'classic' sum of products issues. The EWG will try to ensure good documentation of landings and discard treatment in future and is grateful for the information so the report has been improved, and the issue clarified.

The issue of the peaks in SSB in early years has been checked, an error in the stock weights was found. However, it is possible for this species to exhibit large rapid fluctuations in biomass as it is short lived with variable recruitment. These values have been corrected and the SSB and TSB revised in the early years. There is no change to fit in the assessment, as the issue only influenced the stock biomass which is not explicitly fitted in the model. As the assessment numbers and fishing mortality are unchanged there is no change to any aspect of the advice.

8 – For cuttlefish GSA 17-18, a CMSY method has been applied using the catches and MEDITS survey index. Taking into account that the haul occurrence of cuttlefish in MEDITS is variable probably due to survey timing (occurrence can be from 2% to 30%) it is not advisable to use MEDITS as a survey index for cuttlefish. The diagnostic shows big differences in the analysis of viable r-K.

The origin of catch data is summarised in Table 6.5.2.1.2. There is a key at the base of the table that indicates the origin of the data. There is a small part of the data 2000 to 2007 Italy GSA 17 and 18 that was filled in based on a regression analysis. In the other periods species composition was assumed constant, when multiple species were reported as part of the dominant cuttlefish catch. The documentation of this approach has been improved in the report, and the EWG will continue to work on further analysis of historic data.

The survey data do appear to pick up some signals and the use of the survey helps with stabilisation, the residuals show how little influence it is having in the fine detail. That seems appropriate given the variable recruitment and variable survey values.

The sensitivity of r-k is not unusual for surplus production models. A great many sensitivity runs were carried out and only after extensive testing was the model considered suitable to give an indication of abundance over time. The judgement of whether or not to accept such a CMSY model is marginal. In this case the extended time series appears to give a better assessment than on previous occasions. The fitted model is reflecting the long term broadly stable mean but annually fluctuating catch in Figure 6.5.2.1.1. Given this is such a short lived species here there is nothing in this data to infer important overexploitation, rather the opposite the stock appears to be rapidly fluctuating around a long term mean, without signs of depletion. The advice that is really inferred from the model consists only of stock status advice, which is well supported by the long term catch data. No substantive catch advice is given as the species is too short lived for catch predictions.

9 – For sole GSA 17, t_0 has been modified from -0.46 to 0.58 and used to carry out a length slicing for the a4a model. This choice is completely misleading for sole because the species is a winter spawner and the birthday is considered as the 1st of January, so there is no need to modify t_0. The assessment in a4a is carried out from age 1 because age 0 is missing in the catch at age matrix coming from the slicing. This is could lead to inaccurate conclusion because age zero is routinely fished and is impossible that the Fat age for age 1 is 0 and this model misspecification has a clear impact also in the estimate of $F_{0.1}$. Also, retrospective analysis should be carried out for at least 5 years and not only for 1 year backward. A revision of the ageing is going to be carried out at the beginning of 2019 providing much more accurate estimates for older ages because the lab involved in the ageing are working on sectioning the otolith of big specimens (i.e. bigger than 28 TL). This would probably solve the issues of cryptic biomass observed in previous SS3 assessments.

The STECF has decided to give advice for sole in 17 following the procedure of April 2009. The EWG looks forward to the improved data, and will in the meantime look in detail at the length slicing approach, which has issues if T0 is taken positive or negative. The a4a assessment has been checked and some modifications to natural mortality and maturity vectors incorporated. The assessment has been checked for sensitivity to definition of aging given the growth curves, the results are not sensitive to whether the start year is taken with a positive or negative t0. Overall the STECF advice is based on the SS3 assessment, the catch advice is similar and stock status in terms of F/Fmsy is unchanged. Errors were found in the catch tables, for SS3 these were corrected but did not affect the assessment of catch advice.

10 – For spottail mantis shrimp in GSA17-18, the assessment is carried out with data until age 6+. This is biologically impossible taking into account that *Squilla mantis* is a short lived species with a longevity to a maximum of 4-5 years but usually 3 (Froglia, 1996; Maynou et al., 2005). In addition, the a4a shows a dome shaped catchability but non-justification is provided about this. The retrospective pattern of a4a is quite unstable especially for recruitment.

The assessment this year and last year (accepted by STECF) are based on the same growth curves coming from Froglia 1996. These curves are fully compatible with ages up to 6 years with asymptotic growth to 41mm. The EWG will consider the model parameters again when any update of spottail mantis shrimp.

The dome shaped selection is present in both survey and fishery. The effect was more pronounced if F at older ages was allowed greater flexibility. Reducing the flexibility in F at age and q at age to age 3 resulted in strong residual patterns so the data in both index and fishery support the rather limited doming which is not considered too substantial. The EWG noted the retrospective pattern in recruitment, but was primarily concerned with estimation of F. Data on recruitment is sparse, so necessarily recruitment retros are poor. This point was fully highlighted in the summary sheet section 5.7. and brought to the attention of those reading the main advice sections. The EWG places most emphasis on F estimation as this is regarded as the most important parameter for stock status and advice.

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11 List of Background Documents

Background documents are published on the meeting's web site on: https://stecf.jrc.ec.europa.eu/ewg1816

List of background documents:

EWG-18-16 – Doc 1 - Declarations of invited and JRC experts (see also section XX of this report – List of participants)

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STECF

The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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